

The SCIENTIFIC MONTHLY

December 1944

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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Founding and Organization

In 1848, on September 20, the Association was formally organized and held its first meeting; in 1874 it was incorporated under the laws of the Commonwealth of Massachusetts and given the right to receive, purchase, hold and convey property. Its governing body is a Council, now having 255 members.

The Association is national in scope, with membership open to the whole world on equal terms, and its interests include the broad fields of the natural and the social sciences. Its varied activities are carried on under 16 sections with which 189 affiliated and associated societies, having a combined membership of nearly a million, cooperate in organizing programs for its meetings.

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names of many university presidents, of eminent scholars in widely different fields, and of men notable for public service, including a United States Senator, a Justice of the Supreme Court, and a former president of the United States, are now on its roll of more than 25,000 members.

The Association's meetings are field days of science attended by thousands of participants at which hundreds of scientists vie with one another for the pleasure and the honor of presenting results of researches of the greatest benefit to their fellow men. An enlightened daily press reports their proceedings throughout the country.

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A world torn by conflicts and fearful of the future is looking more and more toward scientists for leadership. The opportunity for unparalleled service is theirs and the fact that they have available the only essentially new methods, if not purposes, imposes an equal responsibility. For these reasons it will be the Association's steadfast purpose to promote closer relations among the natural and the social scientists, and between all scientists and other persons with similar aspirations, to the end that they together may discover means of attaining an orderliness in human relations comparable to that which they find in the natural world about them.

MEET THE AUTHORS



Signal Corps Photo

BRIGADIER GENERAL JAMES STEVENS SIMMONS, M.D., Ph.D., D.P.H., Sc.D., is Chief of Preventive Medicine Service in the Office of The Surgeon General, U. S. Army, Washington, D. C. He was born in Newton, North Carolina, in 1890 and lived in that State until 1916 when he entered the Medical Corps of the

regular Army. He graduated from Davidson College in 1911 and from the University of Pennsylvania School of Medicine in 1915. Both schools subsequently conferred upon him the honorary degree of Sc.D., as did Duke University and Marquette University also. Known for his research and teaching in bacteriology, tropical medicine, and preventive medicine, General Simmons is much in demand as a member of every important national committee dealing with public health and as a visiting lecturer in preventive medicine and public health on the medical faculties of some of our leading universities. Prior to the war he taught for many years at the Army Medical School. The American Public Health Association awarded him its "1943 Sedgewick Memorial Medal for Distinguished Service in Public Health."



LESLIE A. HOLMES, Ph.D., is Associate Professor of Geography and Geology at Illinois State Normal University and is also Administrative Assistant to the President of the institution. He was a high school teacher and a professional petroleum geologist before joining the

faculty of Illinois State Normal University in 1936. While a graduate student at the University of Illinois, he received an American Petroleum Institute Scholarship and a full-time research fellowship. His interests have been in economic geography and geology, particularly in the fields of petroleum and coal. While in his present position Dr. Holmes has served as director of geography field trips and has conducted classes to the east and west coast of North America.



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NEW BOOKS*

Prodigal Genius, The Life of Nikola Tesla. JOHN J. O'NEILL. 326 pp. \$3.75. 1944. Ives Washburn, Inc.

For a scientist the biography of any famous scientist is attractive. But when the subject was generally regarded as a genius, as was Tesla, and the biographer is a professional science writer, as is O'Neill, the product should be extraordinary.

Your Servant the Molecule. WALTER S. LANDIS. 238 pp. Illus. \$2.75. 1944. The Macmillan Co.

The author, who is Vice President of the American Cyanamid Company, has, as it were, brought Slosson's *Creative Chemistry* up to date. His book is intended to inform the layman of the part that chemistry plays in the production of the material things of life, including food.

Science in Soviet Russia. Papers presented at the Congress of American-Soviet Friendship. 97 pp. \$1.50. 1944. Jacques Cattell Press.

Fourteen American scientists, some of whom were born in Russia, present their estimates of progress being made in the U.S.S.R. in various fields of science and technology and in public health and wartime medicine. This book should stimulate the study of scientific Russian.

Enough and to Spare. KIRTLEY F. MATHER. 186 pp. Illus. \$2.00. 1944. Harper & Bros., New York and London.

This little book might be called "Mather's Thesis," in which he attempts to demonstrate that the growth of the world's population does not preclude the attainment of freedom from want, provided full use is made of scientific knowledge and international co-operation is obtained.

Thomas Jefferson and the Scientific Trends of His Time. CHARLES A. BROWNE. 363-423 pp. Illus. \$1.25. 1944. *Chronica Botanica*, Vol. 8, No. 3.

Again Dr. Browne produces a biographical-historical study of the state of science in the early days of this country. In this monograph scientific trends are examined through the writings of Thomas Jefferson, who was vitally interested in the advancement of science.

The Universe Around Us. SIR JAMES JEANS. 297 pp. Illus. 4th Ed. 1944. \$3.75. The Macmillan Co.

Although this is the fourth edition, it is noticed because "a large part of it has been rewritten" to show that the star and the atomic nucleus have met and thrown light on one another. This book should bring laymen up to date on astronomical science.

Radio's 100 Men of Science. ORRIN E. DUNLAP, JR. 294 pp. Illus. \$3.50. 1944. Harper & Bros., New York and London.

Thumbnail sketches are given of the life and work of those who developed the science of electricity and contributed most to the development of radio. Portraits are shown of all but four of the scientists concerned. The sketches are arranged in chronological order of birth.

* Orders for the books noticed above should not be sent to THE SCIENTIFIC MONTHLY or the A.A.A.S., but to your bookseller or the publisher.

MEET THE AUTHORS, Continued



CHARLES MILTON, Ph.D., has the title of Geochronist in the Geological Survey, U. S. Department of the Interior, Washington, D. C. He was born in New York City in 1896. His education appears to have been peripatetic, irregular, and interrupted. Finally he settled down at the University of Illinois,

where he developed his interest in mineralogy under the late Professor W. A. Bayley. In 1926 he went to Venezuela with the Sun Oil Company. After two and a half years he returned to the United States and entered the Johns Hopkins University. He shortly thereafter became connected with the Sinclair Oil Company, setting up a laboratory in New York City for the study of five thousand African drill samples. In 1929 he completed this work, and at the same time received the Ph.D. from Johns Hopkins. Dr. Milton then went to Angola, Portuguese West Africa, as geologist for Sinclair. After a year he returned to the United States and engaged in consulting work on slags, boiler scales, etc. In 1931 he entered the Geological Survey.



PAUL BROCKETT until recently was Executive Secretary of the National Academy of Sciences. Now retired, he is living at the Cosmos Club, Washington, D. C. He was born at Shawneetown, Illinois, in 1872. He entered the service of the Smithsonian Institution (U. S. National Museum) at

the age of fourteen, finally becoming Librarian of the Smithsonian Institution. In 1913 Mr. Brockett became Assistant Secretary and Assistant Treasurer of the National Academy and later was elected Executive Secretary of the Academy, serving until his retirement in 1944. On completion of the Academy building in 1924 he was appointed Custodian of Buildings and Grounds of the National Academy of Sciences and National Research Council. His principal publication was a Bibliography of Aeronautics in fourteen volumes, all but the first published by the National Advisory Committee for Aeronautics.

MEET THE AUTHORS, Continued



DUANE KOENIG, Ph.D., is Assistant Professor of History at the University of Missouri where he teaches upper class courses in Italian history and contemporary Europe. He was born at Kinde, Michigan, in 1918, attended public schools in Michigan and Wisconsin, and graduated from the University

of Wisconsin after having majored in Italian. Continuing at Wisconsin in European history, he concentrated on Italian history, taking his Ph.D. with a thesis entitled "The Napoleonic Regime in Tuscany, 1807-1814." During his last two years at Wisconsin he held research fellowships and collected materials for a critical bibliography of Italian history since 1789. In 1938 Dr. Koenig traveled in Italy, the Levant, and North Africa.



ARAM BOYAJIAN, A.B., E.E., is a development engineer with the General Electric Company at Pittsfield, Massachusetts. He was born in Armenia in 1888. After studying at Anatolia College, he decided to come to the United States, having heard much about the wonders of this country. He was

not disappointed and has since been very proud and appreciative of his American citizenship. He studied electrical engineering at Swarthmore College where he became a member of the Society of Friends. He has been with the General Electric Company ever since his graduation from Swarthmore in 1915. Since 1927 he has served as non-resident instructor of electrical engineering at the Massachusetts Institute of Technology. His intellectual diversions from engineering are philosophy and patent law. For recreation he takes pleasure in concerts and in walking to and from work. Mr. Boyajian has taken an interest in Americanization of new citizens and has helped to organize a library club to improve the financial condition of the local library, of which he is a trustee. He was among those naturalized Americans who were honored at the New York World's Fair for having made contributions to science and engineering.

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MEET THE AUTHORS, Continued



BARBARA WHITNEY, B.A., is the wife of Captain Paul C. Whitney of the U. S. Coast and Geodetic Survey. They live at 5212 Carillo Avenue, Norfolk, Virginia. Mrs. Whitney is from North Dakota and took her degree from the State University. Poetry is her craft, and she is a member of the National League of American Pen Women in which she has served as Chairman of Poetry for the District of Columbia Branch. Her poems have been published in many well-known magazines and newspapers and have appeared in poetry journals and anthologies. Captain Whitney gave her the inspiration for her present poem one very starry night when he said that the light from the unseen stars is greater than the light of all the visible stars, a statement made by Dr. Harlan T. Stetson.



BRIGADIER GENERAL EUGEN G. REINARTZ, M.D., F.A.C.P., F.A.M., since 1941 has been Commandant, Army Air Forces School of Aviation Medicine, Randolph Field, Texas. He was born in East Liverpool, Ohio, in 1889 and received his medical education at Medico-Chirurgical College, Philadelphia, graduating in 1916. During the first World War he was commissioned a first lieutenant of the Medical Corps of the Regular Army and served with the Aviation Section of the Signal Corps. In 1919 he was assigned to the Aeronautics Division of the Aviation Section Signal Corps and has had continuous service with aeronautics since that time; thus he now has the longest continuous service of any medical officer assigned to the Army Air Forces. Space is lacking to describe his many tours of duty in and out of the States. It might be mentioned, however, that prior to this war he served at Corregidor, Nichols and Clark Fields in the Philippines and at Hickam Field, T.H. In 1943 the Institute of Aeronautical Sciences bestowed upon General Reinartz the John Jeffries Award for outstanding contributions to the advancement of aeronautics through medical research.

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MEET THE AUTHORS, Continued



ROBERT BRUCE LINDSAY, Ph.D., has been Chairman of the Department of Physics at Brown University since 1934. In 1936 he became Hazard Professor of Physics. Dr. Lindsay was born in New Bedford, Massachusetts, on the first day of the twentieth century. At Brown University he specialized in physics and mathematics. His graduate work at M.I.T. was concluded by a year of study of the quantum theory of atomic structure in Copenhagen, under Niels Bohr and H. A. Kramers. His Ph.D. was awarded by M.I.T. in 1924, part of his thesis on the atomic models of the alkali metals having been completed in Copenhagen. From 1923 to 1930 he taught physics at Yale and in 1930 he went to Brown. Dr. Lindsay's primary interest is in the teaching of physics, both undergraduate and graduate. His principal intellectual hobby is the collection of books relating to the lives of scientists of all kinds. His principal nonintellectual hobby is walking, of which he does an average of five miles a day the year round. Dr. Lindsay is a prolific writer on topics in theoretical physics, acoustics, and the philosophy of physics.

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CHARLES F. MULLETT, Ph.D., is Professor of History at the University of Missouri. He was born in England in 1902, grew up in central New York, and graduated from Syracuse University in 1922. His graduate work was done at Clark University and Columbia. After some preliminary teaching experience in New York and Indiana, he began teaching at Missouri in 1925. Dr. Mullett's primary historical interests are in the realm of ideas and he has written extensively for scholarly journals on science, religion, and imperialism. During 1937-38 he held a research fellowship at the Huntington Library.

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CHARLES I. GLICKSBERG, Ph.D., is a teacher of English at Southside High School, Newark, New Jersey (see p. iv of the July issue).

THE SCIENTIFIC MONTHLY

DECEMBER, 1944

WARTIME IMPORTANCE OF TROPICAL DISEASES

By BRIGADIER GENERAL JAMES STEVENS SIMMONS

WAR has focused the spotlight of interest on many diseases which previously were little known and seldom thought of in this country. Until recently the American public derived its limited knowledge of tropical diseases largely from vague descriptions of their imaginary horrors brought back by world travelers and foreign missionaries. People are now keenly interested in these exotic diseases because their fathers, broth-

ers, and sons are fighting in the pest-ridden tropical countries of all the continents of the world (Fig. 1). They want to know more about these diseases and what the Army is doing to prevent them. They also wonder whether certain of these infections may be brought home with the troops and constitute a menace to the health of their communities. These three questions are important to all of us. I shall therefore indicate briefly the



FIG. 1. COMBAT IN THE TROPICS, MAKIN ISLAND

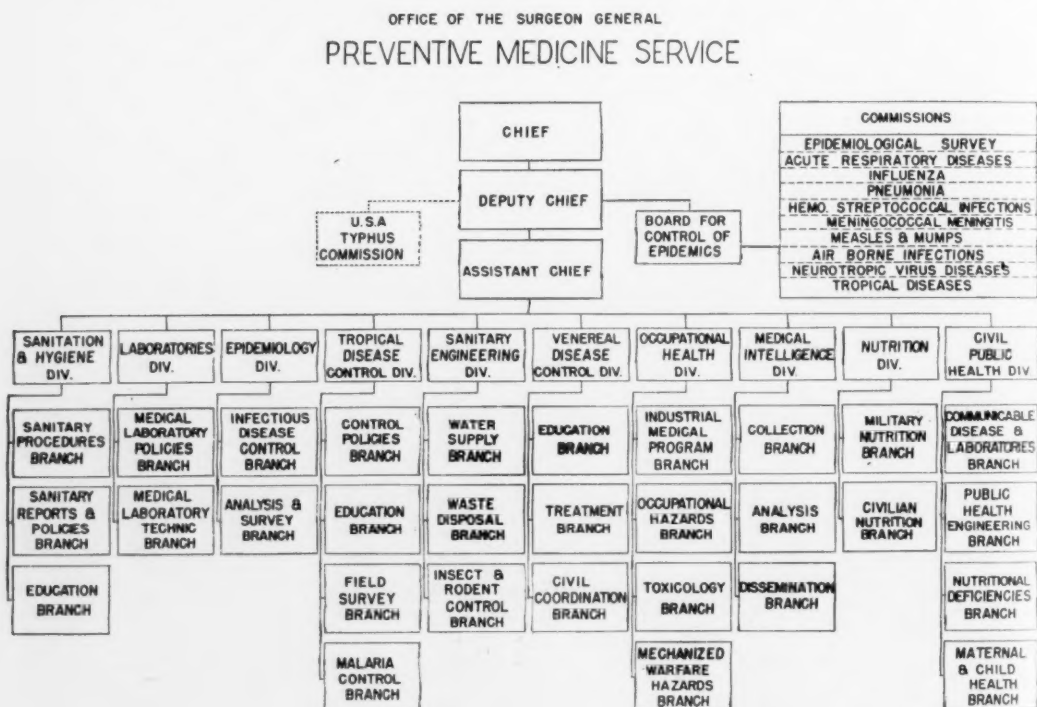
Signal Corps Photo

military importance of the various tropical diseases encountered by our Army, consider the program which has been developed for their control, and, finally, present an estimate of their probable significance to the public health of the nation after the war.

First of all I should like to point out that while tropical diseases have never received the attention of the American public that they do today, these diseases have long been of intense interest to the United States Army. Malaria has been a military problem since the Revolutionary War. After the Spanish-American War the establishment of our outposts in the Philippines, Panama, and Puerto Rico presented the Army with new problems in the control of tropical diseases and new opportunities for their investigation. Thus for a long time the prevention of such diseases among troops has been a matter not only of interest, but of concern, to the Medical Department of the Army.

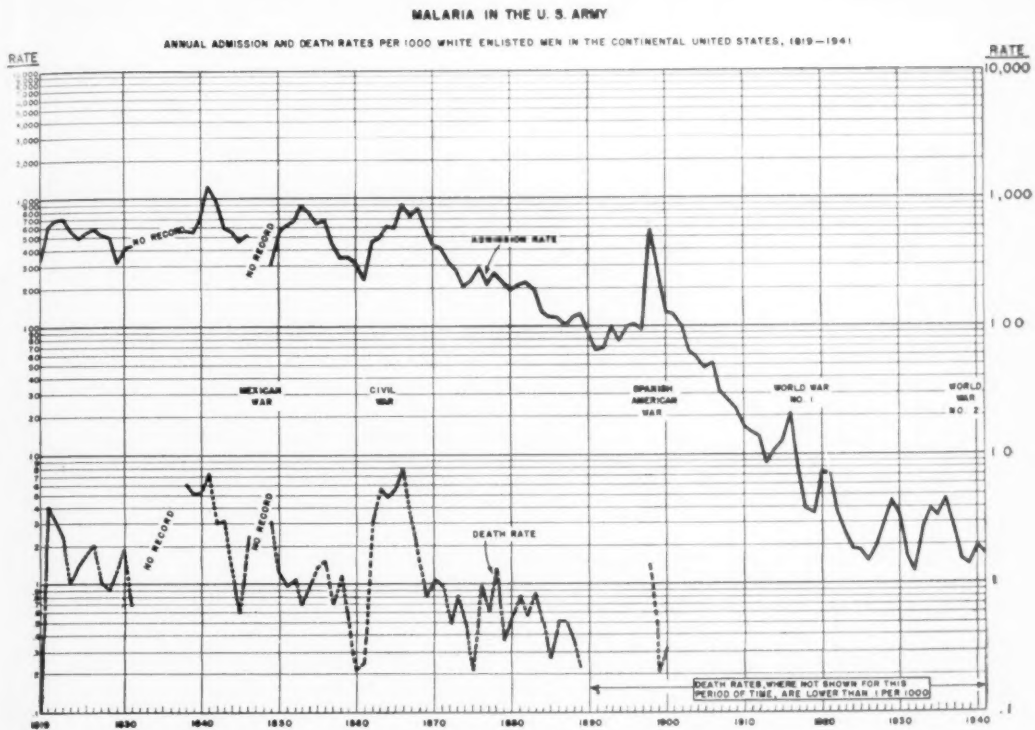
When it became apparent in 1940 that this country might be drawn into the present world conflict, The Surgeon General began to

organize and prepare the Medical Department to meet any situation that might arise. The Preventive Medicine Service (Fig. 2) was established and expanded in his office. This Service includes a Tropical Disease Control Division, which co-ordinates all the Army activities for the prevention of such diseases. The control program has been built up with the assistance of the Commission on Tropical Diseases of the Board for the Control of Epidemics in the Army, which is composed of civilian consultants to the Secretary of War. Serving on this Commission are some of the country's leading experts in tropical medicine. A Subcommittee on Tropical Diseases, formed by the National Research Council at the request of The Surgeon General, has also helped to advise the Army concerning the treatment and prevention of such infections. Later, under the auspices of the Committee on Medical Research, Office of Scientific Research and Development, a comprehensive investigative program dealing with tropical diseases was undertaken for the armed forces with the advice of the National Research Council.



U. S. Army Medical Museum Negative No. 81089

FIG. 2. ORGANIZATION OF THE PREVENTIVE MEDICINE SERVICE



U. S. Army Medical Museum Negative No. 73243

FIG. 3. MALARIA IN THE U. S. ARMY, 1819-1941

Many institutions and agencies are now making both laboratory and field studies, and many thousands of dollars are being spent monthly in the search for more effective drugs, insecticides, and repellents with which to combat exotic diseases. Through this comprehensive wartime research program great progress has already been made in tropical disease prevention.

As the Army expanded to wartime strength, there was a concurrent expansion of the Medical Department. Four years ago the peacetime Regular Army Medical Department consisted of only about 1,000 officers of the Medical Corps and a few hundred additional members of the Dental, Veterinary, and Medical Administrative Corps. At present it includes over 40,000 Medical Corps officers alone, and its total strength is more than 100,000. In addition there are several hundred thousand Medical Department enlisted men. In fact, the present Medical Department is larger than the total Regular Army before this war. Doctors, sanitary engineers, and technicians, skilled

in every phase of preventive medicine and public health, have been brought in from civil life. Most of these experts were unfamiliar with the problems of health maintenance peculiar to tropical regions. Special training was therefore provided for these men after they came in the Service in order to orient them in this new speciality before going into the field, for never before has the United States Army conducted such large-scale military operations in the tropics. It is much more difficult to protect troops from disease during battle than to prevent the same diseases among soldiers living at well-established posts where sanitary conditions can be carefully controlled and hygienic standards of living enforced. Therefore the experience of this war is a real test of the effectiveness of the Army's preventive medicine program.

For more than two years American forces have been operating extensively in tropical areas. From this experience it is possible to evaluate the military importance of the various exotic diseases to which our troops

have been exposed. Many infections which have long been notorious as scourges of native populations in various parts of the world have been of little or no importance to our forces. For example, African sleeping sickness, long recognized as a fearful handicap to the natives of certain parts of Africa, has not been reported among the officers and soldiers who established and operate the Air Transport route across the endemic area of this disease. Schistosomiasis, which is widespread among the natives of many regions, has been acquired by only a few of our troops based in such endemic areas as Puerto Rico, Egypt, and North Africa. Other well-known tropical infections, including leishmaniasis, onchocerciasis, yaws, leprosy, yellow fever, plague, and cholera, have either failed to occur or their incidence has been so low that it has not affected the health record of our Army.

A few tropical diseases, however, have

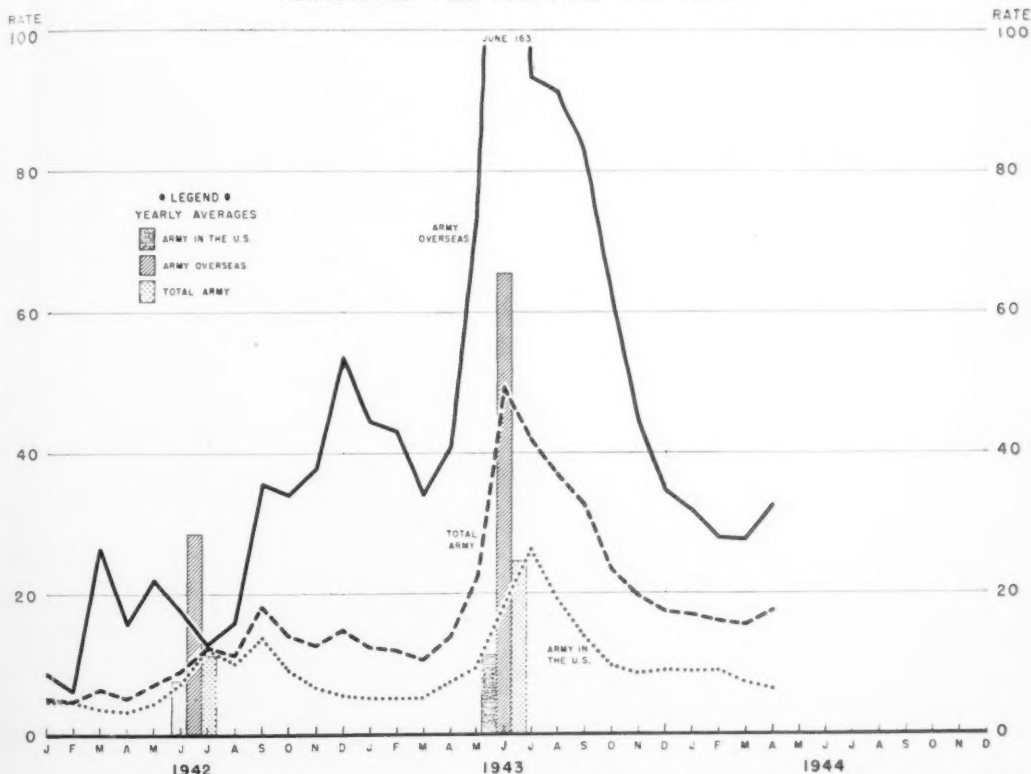
been of distinct military significance, not because of their mortality, but because of the incapacity and the loss of time which they have caused. Malaria has been the number one hazard, and the dysenteries have also been an important cause of noneffectiveness. Dengue fever, sandfly fever, filariasis, and scrub typhus have at times caused concern in certain areas. All of these infections are either transmitted by insects or, as in the case of dysentery, insects play a significant role in their spread. Effective vaccines are not available for any of them. For this reason, the development of new and more effective insecticides and insect repellents has constituted one of the most important parts of the Army's preventive medicine program. Through the assistance rendered by the research agencies of the nation, we are now armed with a number of effective new weapons. These include potent insect repellents, the freon-pyrethrum aerosol



FIG 4. MOSQUITO CONTROL ON GUADALCANAL

Signal Corps Photo

DIARRHEA AND DYSENTERY U.S. ARMY ADMISSIONS PER THOUSAND PER ANNUM



U. S. Army Medical Museum Negative No. 81742

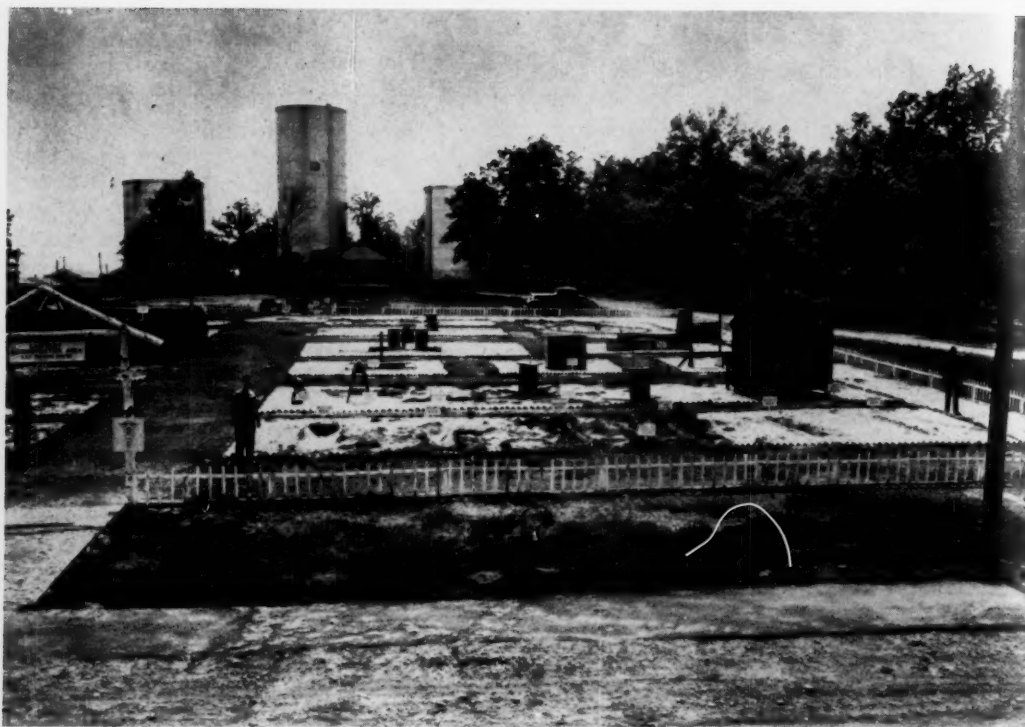
FIG. 5. DIARRHEA AND DYSENTERY IN THE U. S. ARMY

bomb, methyl bromide for delousing clothing, and, finally, the greatest of all, DDT, for use both in the control of lice and mosquitoes. The basic research and development for military purposes of the four items just mentioned was done by the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture. The discovery and the field application of DDT to the control of insect-borne diseases, will, in my opinion, prove to be the outstanding medical advance made during this war. It will exceed even penicillin in its ultimate usefulness in the preservation of health and the saving of human lives.

Malaria has always been the enemy of armies fighting in hot and warm climates, and ours is no exception (Fig. 3). In this country the Army has carried on an enormous antimosquito campaign since 1941. This has been supplemented by the equally

extensive extramilitary mosquito campaign of the Public Health Service. Together they have reduced malaria among the troops at home to the lowest point ever reached. In certain tropical theaters, however, the malaria casualties have been an important factor in military operations. In some of the early campaigns, the malaria rates were high. Because of military situations men fought in hyperendemic regions without adequate anti-malarial supplies and without benefit of mosquito control (Fig. 4). Great improvement was made in later campaigns. The incidence rates in the most highly malarious theaters are now less than one-fourth of what they were early in the war. On the whole the Army has had a good record in preventing malaria, and the death rate has been negligible.

The dysenteries are a constant menace to armies in the field. Their control is much



U. S. Army Medical Museum Negative No. 81685

FIG. 6. SANITARY DEMONSTRATION AREA AT FT. DEVENS, MASS.

more difficult in tropical countries where standards of sanitation are primitive and troops are more exposed to both the bacillary and amoebic forms of the disease. The incidence rates for the diarrheas and the dysenteries have at times been a matter of concern (Fig. 5). There have been no great epidemics, however, and the total prevalence has been less than in other armies during this and past wars. Our troops are provided with every possible sanitary safeguard (Fig. 6) to protect them against intestinal diseases.

At fixed installations all Army water supplies meet modern sanitary standards. Proper garbage and waste disposal, together with screening and the use of insecticides, keep down the potential menace of flies. During field operations the problem of dysentery prevention is more difficult and, like the control of malaria, depends more directly upon the individual soldier. Thorough training in sanitation is given to everyone in the Army, and, in general, high standards prevail. Captured Japanese camps offer a

shocking comparison with the excellent sanitation maintained by our own troops.

The Rickettsial infection known as *scrub typhus* has been of considerable military importance in the Pacific and Asiatic theaters. It is transmitted by larval mites which infest the long Kunai grass (Fig. 7) of New Guinea and the jungle undergrowth of other Far Eastern regions. Unfortunately, we do not have an effective vaccine. The number of troops acquiring scrub typhus has not been large, but the disease causes concern out of proportion to its prevalence because of the mortality rate, which has ranged from 3 to 10 per cent.

Last year The Surgeon General sent to New Guinea a Commission, formed under the auspices of the Army Board for the Control of Epidemics and the U. S. A. Typhus Commission, to investigate scrub typhus and recommend preventive measures. Fortunately the repellents used to control malaria are also effective in protecting soldiers against the mite vectors of scrub typhus,

especially when they are applied to the clothing. Scrub typhus will remain a problem as our forces continue their advance to the Asiatic mainland.

Filariasis has long been a notorious example of the terrifying infections to be found in tropical countries. The monstrous deformities of the legs (Fig. 8) and other parts of the body, depicted in textbooks for tropical medicine, have created a feeling of disgust and horror in the minds of most readers. As a rule the disease occurs only among the

the men infected, filariasis has not been a problem of real military significance in the Army. It will probably be of no real importance in this country, and its spread is not anticipated.

Dengue fever and *sandfly fever* are non-fatal, disagreeable diseases of short duration. They may, however, assume considerable military importance when large numbers of susceptible troops are exposed to infection for the first time. Under such circumstances both diseases tend to appear in ex-



Signal Corps Photo

FIG. 7. SCRUB TYPHUS CONTROL ON GOODENOUGH ISLAND

natives of the endemic areas. However, under conditions of war, considerable numbers of men stationed in the South Pacific Islands have acquired the infection and have manifested early symptoms. Such men have been returned to this country to avoid exposure to further infection. Continued reinfection over a long period of years is apparently necessary to produce deformities grave enough to warrant the term 'elephantiasis.' Although it has been a source of annoyance and of some mental anxiety to

plosive epidemics, thus incapacitating large numbers of men within a short time. Dengue has occurred most frequently in our forces in the Pacific, while sandfly fever has been most common in the North African and Middle East Theaters. During the Sicilian Campaign cases of sandfly fever were numerous, and in some instances the disease was confused with malaria. The method of choice for their prevention is control of the respective insect vectors. The new insecticides and repellents developed to combat



Courtesy of Colonel Richard Strong*

FIG. 8. ELEPHANTIASIS OF THE LEGS

malaria can be successfully employed against the *Aedes* mosquito vectors of dengue and the *Phlebotomus* vectors of sandfly fever.

The intestinal parasites, especially hookworm, are common in tropical countries. Many of our soldiers are exposed to infection with the latter as they crawl through the jungle (Fig. 9) or dive into air raid shelters or trenches previously contaminated by natives. It is known that a considerable proportion of some units in the Pacific have acquired uncinariasis, but as a rule the infections have not been severe enough to cause noneffectiveness. It may be expected, however, that many of the men who have served in the tropics will come back with intestinal parasitic infections, both helminths and

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protozoa. Therefore, careful stool examinations should be made a routine procedure when such individuals apply for medical care.

The question as to the possible spread of tropical diseases in the United States by troops returning from overseas has captured the imagination of the entire country. For more than a year it has been a subject of wide discussion by the medical profession, lay officials, and the general public. Undoubtedly such diseases will be introduced from abroad, but on the whole I believe that the future dangers have been overemphasized. Only a few of the many tropical diseases have been of appreciable importance in the Army. The majority of such diseases have either failed to occur among our troops, or their incidence has been so low that the possibility of their introduction into the United States by returning soldiers cannot be considered as a public health problem. It is true that new foci of malaria and perhaps other infections may be established. However, by maintaining the present preventive safeguards and by taking prompt preventive action, it should be possible to control such potential outbreaks quickly and effectively. The high standards of personal hygiene, sanitation, and preventive medicine that exist in the United States are believed to offer good safeguards against serious consequences from the introduction of exotic diseases. The Medical Departments of the Army, Navy, and Public Health Service are fully aware of this problem and are prepared to deal with any trouble that may arise.

The most important task connected with the return of such infected personnel is to insure prompt diagnosis and proper treatment of symptoms which may occur after the troops have returned to civil life. This means that every physician in this country should be able to recognize and treat tropical diseases. This in turn indicates the need for what has already been started; namely, the development of more adequate training in tropical medicine in all of our medical schools.

The importance and interest in tropical diseases which have developed during this war will not decrease with the cessation of

*Signal Corps Photo*

FIG. 9. JUNGLE FIGHTING ON BOUGAINVILLE, FEBRUARY, 1944

hostilities. Undoubtedly we shall maintain bases in many faraway places, including locations in the tropics. Our troops stationed overseas will continue to require an intelligent application of the knowledge that has been gained in the prevention of tropical diseases. The volume of travel between this country and the tropical regions of the world will increase. The speed of travel by mod-

ern aircraft will increase the chance of introducing tropical diseases and disease vectors. The future health program of the country will be more closely knit with international health. The hazards of tropical diseases will become more world-wide, but these hazards can be met and neutralized if we continue to develop the knowledge and the health facilities now available for that purpose.

RECLAIMING STRIPPED LANDS IN ILLINOIS

By LESLIE A. HOLMES

It is indeed unfortunate that the term 'spoil bank' or 'strip mine dump' became associated with the strip mining industry. Both 'spoil' and 'dump' mean something undesirable, to say the least, to the average American; so upon hearing the words 'spoil bank' one visualizes an area of ground torn up by man and piled into unsightly dumps, yet the average person going to Yellowstone Park will spend additional money to see the Bad Lands, a rugged area of 25,000,000 acres developed by nature. We tend to see the good side of the Bad Lands, but the bad side of strip mine hills.

Illinois is the leading producer of coal mined by stripping and has one of the largest

acreages of spoil banks in any state (Fig. 1). In 1941, 23,981 acres had already been mined. At that time it was conservatively estimated that the state contained an additional 34,840 acres of shallow coal adaptable to recovery only by the strip mining method. This means that approximately 0.16 per cent of the area of the state may eventually be stripped of its coal. Of this area, 27,932 acres are classed by the Soil Survey Division of the University of Illinois as not adapted to general farming (Fig. 2). This is almost one-half of all the mined or mineable acreage.

Forestation. Because it was recognized that strip mining was taking land off the tax



FIG. 1. A LAKE IN THE LAST CUT OF A STRIP MINE NEAR WILMINGTON FORMED SINCE MINING BY THE NORTHERN ILLINOIS COAL CO. CEASED IN 1929, THE LAKE, FROM THIRTY TO FORTY FEET DEEP IN SOME PLACES, WAS STOCKED WITH GAME FISH. THE TREES WERE SEEDS BY NATURE.



FIG. 2. TYPICAL APPEARANCE OF LAND TO BE STRIPPED IN SOUTHERN ILLINOIS. THE SOIL IN THIS AREA IS THIN AND BADLY ERODED IN MANY PLACES. THE TREES IN THE FOREGROUND ARE THORNY LOCUST AND ELM. THIS LAND IS THE PROPERTY OF THE SOUTHWESTERN ILLINOIS COAL CORP., PERRY.

list and making it unsightly as well, some of the strip mining companies as early as 1930 began experiments designed to reclaim their stripped land for productive use. During that year 42,000 trees were planted. From 1938 through 1943, 8,337,400 trees have been planted at a cost to the mining companies of \$95,637.

When forestation was started nothing was known as to the types of trees that would grow on the dumps, how close to plant them, or what to expect as a survival ratio. For that reason twenty species of trees were commonly planted. The survival ratio proved to be exceedingly high for each species, with the exception of the Osage-orange which had a survival of only 10 per cent. As a result, only 69,500 of the latter have been planted thus far, whereas 2,407,900 black locust trees, with a survival of 92 per cent, have been planted. In addition, 1,804,500 short leaf

pine trees, with a survival of 77 per cent, were also planted (Figs. 3 and 4). Almost all of these plantings were on spoil piles as they were left by the machines and without previous fertilizing or cultivation. In fact only a spade of earth was loosened and the young tree set in.

It is estimated that 8,466 acres have been forested up to the end of 1943. This acreage is about one-third of the land stripped. All the trees were about one year old when they were purchased from the state nurseries, and the cost of planting stock and labor has averaged \$11.00 per acre for the state as a whole.

Financial Returns. One of the major surprises in planting seedlings on strip mine dumps was the fact that in many cases the trees grew faster than those on undisturbed land. On the mine dumps at the Midland Electric Coal Corporation near Atkinson,



FIG. 3. BLACK LOCUST PLANTINGS ON PARTIALLY LEVELED SPOIL BANKS

Left, THE TREES WERE ONE YEAR OLD WHEN PLANTED. THE PICTURE WAS TAKEN SIX MONTHS AFTER PLANTING. *Right*, THE SAME TREES AFTER ANOTHER YEAR OF GROWTH—CENTRAL STATE COLLIERIES, INC., ST. DAVID, ILL.

Illinois, black locust grew to be about twelve feet high in three years, while those planted on undisturbed land nearby grew to be only about six feet tall in the same three years (Fig. 5). It is probable that the undisturbed soil had lost much of its fertility, whereas the soil on the mine dumps was new and unleached, thus accounting for the exceptional growth of trees on the dumps. One of the Illinois state foresters writes, "... generally

speaking trees will grow almost as well on strip mine land as on other soil and in many cases will do better. . . ."

Under normal conditions the sale of lumber and posts over a 40-year period will average \$3.71 per acre a year. This figure is based on extremely conservative estimates of \$5.00 per 1,000 board feet and \$0.10 each for posts. A more recent development in the wood utilization industry is the use of wood



FIG. 4. SHORT LEAF PINE PLANTED ON SPOIL BANKS

Left, A TWO-YEAR GROWTH OF TREES ON THE PROPERTY OF THE PYRAMID COAL CORP., PINCKNEYVILLE, ILLINOIS. *Right*, TREES PLANTED FOR FIVE AND ONE-HALF YEARS—TRUAX-TRAER COAL COMPANY, ELKVILLE, ILLINOIS.



FIG. 5. BLACK LOCUST PLANTINGS

Left, THESE TREES SHOW THREE YEARS OF GROWTH AFTER PLANTING IN UNDISTURBED SOIL NEAR ATKINSON. Right, TREES OF SAME AGE BUT GROWING ON SPOIL PILES, MIDLAND ELECTRIC COAL CORP., NEAR ATKINSON.

chips which will probably be sold by the ton. In this manner slabs, trimmings, and stumps will be as marketable as the trunk. Cottonwood trees are particularly well adapted to this processing, and more trees of this type are to be planted in the near future. Evergreen trees may be used after five or six years for Christmas trees, and posts may be obtained from locust plantings in ten to fifteen years. With a proper rotation of tree crops, the per acre value of wood can be stabilized at perhaps \$5.00 rather than \$3.71 previously quoted. Later there is a possibility that valuable lumber and nuts may be produced from the 453,500 black walnut trees already planted and from other nut trees still to be planted. On certain spoil banks favorable results have been obtained by planting orchards, berry patches, and vineyards.

Successful forestation, however, has not as yet been achieved in all the strip mine areas. One of the most difficult districts lies south of Wilmington in northern Illinois. In this location the glacial debris and shale immedi-

ately above the coal form a hard, compact mass so nearly impervious to water that it will not support tree growth, except in localized places. Near Morris and Ottawa, also in northern Illinois, successful forestation has thus far been impossible because of the large amount of acid in the spoil banks. Some of the mine dumps in Williamson and Saline counties, of southern Illinois, consist so largely of rock and shale that weathering has not as yet progressed sufficiently to produce soil capable of supporting trees. While the outlook for successful forestation in areas of these types is discouraging, the total acreage that has not responded is probably not over 5 per cent of the amount thus far stripped and does not materially change the general picture of forestation for the entire state.

Pasture. A few miles south of Canton, Mr. Byron Somers decided to experiment with the use of spoil piles for pasture. He bought 800 acres of land, 600 of which was

spoil banks acquired from the Truax-Traer Coal Company; the remainder was average Fulton County pasture land. He had noticed that naturally seeded weeds and sweet clover grew in abundance on the piles and that large rocks were scarce. Also he had seen that the numerous small lakes remained clear and fresh and that the large lake in the last cut offered an opportunity for fish stocking since it was 2.5 miles long, over 100 feet wide, and at certain places as much as 45 feet deep.

In 1935 he began to seed the sides of the spoil banks. By 1938 the grasses were sufficiently developed for cattle pasture. Since

tant factor in keeping the grasses green over a long period of time. The usual method of planting is to seed the blue grass in the valleys and let it grow up the sides of the spoil banks. Sweet clover is usually planted along the sides and tops. Many of the top ridges are extremely sharp because no leveling has been done in this area, except enough to permit a rough road to be built through the hills.

After having been fed silage and hay during the winter, cattle are turned onto the seeded banks early in the spring. As these cattle enter the pasture they are usually rangy but not particularly thin. With a



FIG. 6. CATTLE OF MR. BYRON SOMERS, CANTON, ON SPOIL BANK "RANGE"
Left, THESE VIGOROUS ANIMALS FED ALL SUMMER ON GRASSES THAT HAD BEEN SEEDING ON THE MINE DUMP.
Right, THIS AREA, NATURALLY FORESTED, WAS MINED BY TRUAX-TRAER 12 YEARS BEFORE IT WAS PHOTOGRAPHED.

that time beef cattle have been pastured on these lands the year around, except during the coldest winter months. Sweet clover, blue grass, and timothy seem to grow stronger, to be more nourishing, and to remain green longer than on the 200 acres that were not disturbed. The probable explanation, previously mentioned, is that the spoil banks still contain all the original soluble minerals since there has been little opportunity for leaching. Also the ground-water table is higher because the rain falling on the area has no outlet and sinks into the ground or collects in the depressions between the banks. This water, of course, is an impor-

summer's feeding on the spoil bank range they will gain about 200 to 300 pounds each, and in many cases also produce a calf that will weigh from 150 to 350 pounds by autumn (Fig. 6). In 1942, 250 cattle were pastured, and these together with the calves gave a clear profit of \$7,000, or almost \$9 an acre. This profit was greater than could be obtained from an adjacent 400 acres of undisturbed farm land planted in the usual manner. In this case the spoil banks represented a profit of from \$25 to \$35 an animal per year. The rough topography is of no hindrance to the cattle; they graze both on the ridges and in the valleys, and usually



FIG. 7. PUBLIC RECREATIONAL AREA ABOUT A FINAL-CUT LAKE

THIS AREA WAS MINED IN 1928 BY THE MIDLAND ELECTRIC COAL CORPORATION, ATKINSON, ILLINOIS. THE LAKE IS STOCKED WITH GAME FISH, AND THE TREES WERE PLANTED ON THE HILLS BY CONSERVATIONISTS.

rest upon the tops of the ridges where winds reduce fly and mosquito pests to a minimum. It is improbable that similar use of all spoil banks within the state would produce such profits, because some areas, particularly in the southern counties, have much poorer soil and more large rocks and are not as readily adaptable to grazing as those in Fulton County. However, this experiment does show the potential profit to be obtained in certain areas of Illinois, which now has over 2,500 acres of such pasture land. This is about 10 per cent of the area thus far mined.

At its Fiatt mine in Fulton County the Truax-Traer Coal Company is taking the precaution, whenever possible, of piling their mine dumps in such a way that the heavy rocky material and shales are placed on the bottom and the clay and fine soil on top. This company plans in the future to seed all of its spoil banks in this area and eventually

to pasture sheep as well as cattle on the "range." Here per acre profits will probably be greater in pasture than in trees. The mining practices followed by this company can be used by many strip mining companies with little added cost to themselves and to a great advantage in their reclamation work.

Recreation. The irregular hills, valleys, and lakes developed by the stripping machines are ideal for recreational purposes (Fig. 7), especially after becoming naturally forested and grassed or, better still, after being artificially forested and grassed. Fishing, boating, and swimming are frequently enjoyed by visitors to these beauty spots. Game fish seem to do particularly well in the large, deep, cool, and clear lakes made by the last cut of the stripper. Mr. Somers reported that from his stocked lakes a bass

weighing almost seven pounds was taken in 1943. Several weighing five pounds were also caught as were numerous smaller ones. Hundreds of trout have been placed in this lake, but angling for these fish has been prohibited by the owner. Will, Henry, and Vermilion Counties are noted for fishing in mined out lake areas. Many strip mine lakes in southern Illinois have also been stocked.

Game of all kinds, particularly fur bearers, are found in abundance in the rough terrain of the spoil banks. From the pasture land described above, muskrat pelts valued at \$250 and four mink pelts worth \$32 were taken and sold in 1943. Trapping has been exceptionally lucrative on all of the Illinois spoil banks. Quail and pheasants are raised and liberated by some of the companies in co-operation with the State Department of Conservation. Two-thirds of the

birds are released locally in areas other than mine dumps, and the remaining third are liberated on and near the mine dumps where protection is greater than in the adjacent areas. Wild ducks commonly use the lakes in their migratory flights; and duck hunting in these surroundings has been reported as unusually good. In all, about 12 per cent of the strip mine dumps in Illinois are now in recreational areas.

Conclusion. By turning the spoil banks into forest, pasture, recreational areas, and game preserves, all of them may be used to advantage, and many will return a yearly profit to the owner equally as great as that produced by the land prior to mining. Certainly with a minimum of time and labor the great majority of strip mine dumps in Illinois can become "cover hills."

A SCIENTIST'S PSALM*

*Almighty Power! Too vast to be
Compassed by human mind or hand,
With loving awe we reverence Thee,
Striving to see and understand.*

*Within the atom's ordered maze,
Earth's lumined book, writ to be read,
Beyond the star-dust's far flung haze,
We seek Thy works with joy, not dread.*

*Our souls, which by Thy richest grace,
Have waked to justice, mercy, love,
Find in humanity Thy face,
And serving men, serve Thee above.*

—JEROME ALEXANDER

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STONES FROM TREES*

By CHARLES MILTON

THE spectacle of a tree firmly rooted in apparently barren rock, from which it draws its sustenance, is by no means uncommon. In the economy of nature the strong rock is broken down and partly dissolved, and some of its mineral constituents become part of the tissues of the growing plant. The cycle is a very long one, commencing with the fresh crystalline rock, its incipient weathering (permitting a toe-hold, so to speak, by the seedling), the absorption through the roots of the slowly dissolving rock-substance, its incorporation in the wood and leaves of the growing plant, and, with the death of the plant, the dispersion of the mineral matter into leaf-mold humus, or rain-water solutions, and eventual distribution over the land and into the sea. At no time, it would seem, in human history would this mineral matter ever be reassembled so as to form massive stones or rock; and yet, surprisingly, this may occasionally happen.

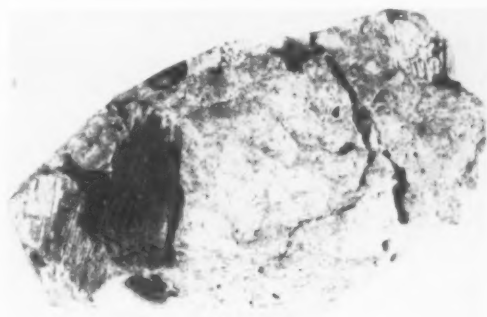
In Figure 1 is pictured such a stone, produced from a tree. It is but part of an originally larger piece, a couple of pounds in weight. Such stones have been found in recent years in at least three localities: Grand Canyon of Arizona, northern Idaho, and southern Washington. In all places the mode of occurrence is similar. The stones are found in the hearts of tall trees that have been through forest fires or have been blasted by lightning. The Arizona specimen was found by William J. Kennedy, a forest ranger who noted the burning, lightning-struck tree shown in Figure 2. In his monthly report for September, 1943, he wrote:

While at a fire on the north side of Kanabowunits Canyon one-quarter mile from the Point Sublime road and four and one-half miles from the North Entrance road on September 11 [1943] the writer found several pieces of a peculiar substance which somewhat resembled a kind of lava ash. They came from a tree that had been hit by lightning and had burned for several days before the fire in it had been discovered. The specimens had pieces of charcoal intermingled with the rock. The top of the tree had

been blown to bits by lightning and no trace of it could be found. The tree was felled during the process of suppressing the fire and upon measurement it was found to be 49 inches in diameter 30 inches above the ground—it was swell-butted at the ground—and it was 36 inches in diameter at the point where the specimens were found, 54 feet above the ground. The tree was a white fir, *Abies concolor* [and grew at approximately 8500 feet elevation]. Several of the specimens were sent to the South Rim.

The other occurrences were in trees that had rotted at the heart, while still standing, and had later been in forest fires. Essential requirements for the formation of the stones are the accumulation of decayed wood or ash surrounded by sound wood, with vigorous burning of the wood subsequently so as to melt down the enclosed ash.

At this point it may be reasonably queried why we do not find these stones when we burn wood in fireplaces or out-of-doors where hot fires have burned above ash beds? If the process were as simple as that, such stones



Natural size

FIG. 1. FUSED WOOD-ASH STONE

IN THIS FRAGMENT OF A SPECIMEN FROM NORTHERN IDAHO NOTE THE CHARCOAL EMBEDDED IN THE STONE.

ought to be quite common, but there is one further essential requirement. The burning of the wood and the melting of the ash must take place with a minimum accession of air (oxygen). In other words, the combustion and fusion must take place under such conditions that the carbon dioxide produced by the burning is in sufficient concentration to support the weight of the overlying air-column. In technical language, the vapor pressure of the carbon dioxide resulting

* Published by permission of the Director, Geological Survey, U. S. Department of the Interior.

from combustion of the wood must approach one atmosphere. The reason for this will be made clear when we study the composition of the stone.

Just as the biologist prepares from his specimens, animal or vegetable, slices or sections of extreme thinness to permit light to pass freely through them, so does the student of stones and rocks make use of thin sections of his materials, a thousandth of an inch, or even less, in thickness. Light passes freely through such thin slices of rock, and most rocks when viewed in such slices under the

in these stones, this compound is unknown as a naturally occurring mineral. It has, however, been produced artificially in the laboratory, and its properties determined by several investigators. As the compound is heated it loses carbon dioxide at an increasing rate until at 813° C. it cannot exist but breaks up into potassium carbonate, lime, and carbon dioxide. However, if the heating takes place in an atmosphere of carbon dioxide, just as many molecules of this gas enter the crystal as leave it, and the substance is then stable.



FIG. 2. A LIGHTNING-STRUCK WHITE FIR TREE, GRAND CANYON, ARIZONA
Left, SHATTERED TOP OF BURNING TREE; *right*, ITS STUMP AND TRUNK, AFTER IT WAS FELLED TO SUPPRESS THE FIRE. THIS TREE WAS THE SOURCE OF WOOD-ASH STONES FOUND BY PARK RANGER, WILLIAM J. KENNEDY.

microscope are as beautifully transparent as a stained-glass window. Of course, the mineralogist cannot use the biologist's steel microtome on hard rocks, but he achieves his end by a process of grinding. In a matter of minutes skilled technicians can prepare from a granite or marble or basalt a continuous unbroken slice inches across and as thin as tissue. Such thin sections may be prepared from our tree stones, and the typical aspect of such, as seen under the microscope, is shown in Figure 3.

It is seen that the stones consist largely of platy crystals which resemble rods or laths in cross section. Chemical analysis of the stones further shows that these crystals are a double carbonate of potassium and calcium ($K_2CO_3 \cdot CaCO_3$). Except for its occurrence

Our grandmothers had more concern with wood ashes than we have: The family soap supply was often made at home from wood ashes, or pot-ash. The ash consisted of potassium and calcium carbonates; by leaching, the soluble potash lye (or leach) was saved, and the insoluble limy residue was discarded. These ashes, however, were obtained by free burning with plenty of air, and in all probability no formation of ash-stones ever occurred; at least, none has been recorded.

But if the ash is melted while enveloped in carbon dioxide from the surrounding burning wood, a condition that obtains when the burning occurs within a standing stump, the ash will fuse together to form our stones. Usually, though, the burning takes place under conditions that cause the dispersion

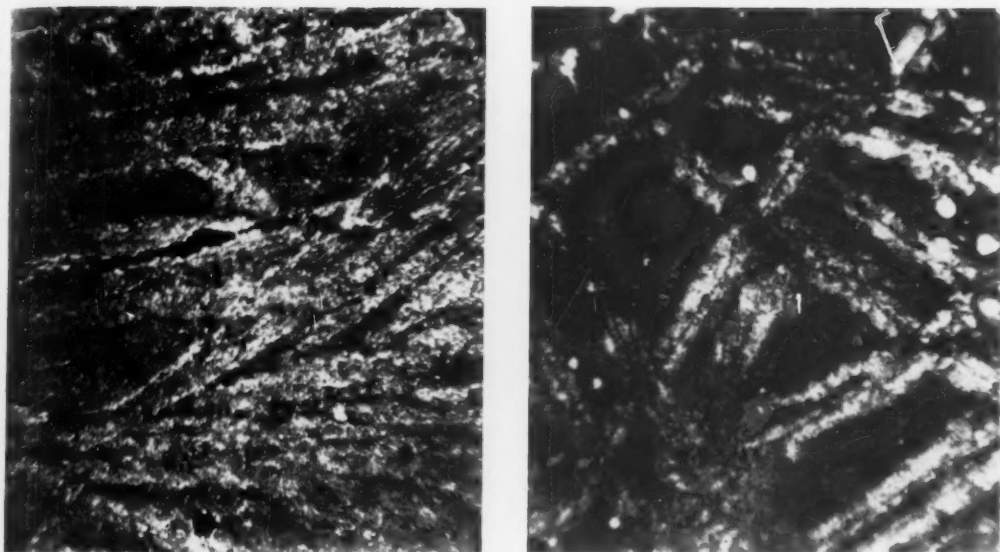


FIG. 3. PHOTOMICROGRAPHS OF A THIN SECTION OF A WOOD-ASH STONE

Left, NOTE ELONGATED CROSS SECTIONS OF CRYSTALS OF POTASSIUM-CALCIUM CARBONATE ($\times 20$); *right*, SAME, AT HIGHER MAGNIFICATION ($\times 50$), SHOWING LATH-SHAPED CROSS SECTIONS OF PLATY HEXAGONAL CRYSTALS.

and scattering of the ash before it can be heated sufficiently, or sufficient air is supplied to the burning tree to sweep out carbon dioxide as fast as it accumulates.

Even if the stones are successfully produced, they still have perils to face. As long as they are dry, they will persist unchanged. But when they are attacked by water—not energetically, but intermittently with intervening drying—the stone may eventually be thoroughly leached of its highly soluble potassium carbonate component; then the residue, still stony perhaps, or perhaps a powdery mass, will be essentially calcium carbonate and apparently in no way different from a piece of crumbly limestone.

It is conceivable that under special conditions of arid climate a wood-ash stone might be preserved through a long geological time. But ordinarily their lifetime will be short, a matter of years only.

Until their nature was understood, various erroneous ideas were held as to the origin of these stones. As the stones occurred in dense forests where no similar rock was to be found and were obviously too large for transportation by birds or animals, it was conjectured that they might be meteorites. As they were found where there had been fire, it was even surmised that they had caused the fire—another instance of erroneous conclusions from circumstantial evidence.

NATIONAL ACADEMY OF SCIENCES MEDAL AWARDS

By PAUL BROCKETT

DURING a period of seventy years, nine funds were established under the National Academy of Sciences to provide medals and honoraria for the recognition of outstanding scientific work. In the following sections each of the nine medals is illustrated, information is given about the award that it represents, and the recipients of each award are listed. The year of award is not necessarily the year in which the medal was presented. With the exception of the Charles Doolittle Walcott Medal (bronze), all are gold medals, ranging from one and three-quarters to three inches in diameter. The medals are discussed in alphabetical order.

ALEXANDER AGASSIZ MEDAL

Sir John Murray, British geographer and oceanographer, was a guest of the Academy at the Annual Dinner on April 19, 1911, when the Henry Draper Medal was presented to Charles Greeley Abbot for his work on the infrared regions of the solar spectrum and his accurate measurements, by improved devices, of the solar "constant" of radiation. Sir John was so impressed by the establishment of an award for original investigations in astronomical physics that he expressed a desire to found, under the National Academy of Sciences, a similar medal for deep sea researches in honor of his friend, Alexander Agassiz, who had died the year before and who had been the leading American investigator in oceanography.

On April 22, 1911, Sir John Murray wrote the following letter to the Academy:

I enclose you a cheque for \$6,000 (£ 1233) which sum I trust the National Academy will accept from me, for the purpose of founding an Alexander Agassiz gold medal, to be awarded for original contribution in the science of oceanography to scientific men in any part of the world, whenever and as often as the President and the Council may deem desirable.

The Sir John Murray Fund, now amounting to \$10,000, was thereupon established. The obverse of the medal bears a three-

quarter bust of Alexander Agassiz; the reverse, a swimming medusa, or jellyfish.

Recipients of the Agassiz Medal

HJORT, JOHAN, 1913
ALBERT I, Prince of Monaco, 1918
SIGSBEE, C. D., 1920
PETTERSSON, OTTO SVEN, 1924
BJERKNES, VILHELM, 1926
WEBER, MAX, 1927
EKMAN, V. WALFRID, 1928
GARDINER, J. STANLEY, 1929
SCHMIDT, JOHANNES, 1930
BIGELOW, HENRY BRYANT, 1931
DEFANT, ALBERT, 1932
HELLAND-HANSEN, BJORN, 1933
GRAN, HAAKON HASBERG, 1934
VAUGHAN, T. WAYLAND, 1935
KNUDSEN, MARTIN, 1936
ALLEN, EDGAR JOHNSON, 1937
SVERDRUP, HARALD ULRIK, 1938
LILLIE, FRANK RATTRAY, 1939
ISELIN, COLUMBUS O'DONNELL, 1942

JOHN J. CARTY MEDAL

The John J. Carty Fund of \$25,000 was established in 1930 by close associates of Dr. Carty when he retired from the vice-presidency of the American Telephone and Telegraph Company. They wished to record for all time evidence of their love, respect, and esteem for him and his work.

The medal bears on the obverse a bust of Dr. Carty; on the reverse below the name of the recipient, a flaming conventionalized sun—the great source of energy—with its rays boldly treated. A monetary award is made with the medal. Both are granted for noteworthy and distinguished accomplishments in any field of science coming within the scope and charter of the Academy and are accompanied by a diploma citing the reasons for the award.

It is stipulated that the award shall not be made oftener than once in two years and that no limitation shall be placed on the selection of a recipient by reason of his race, nationality, or creed. The first award was made posthumously to Dr. Carty.



ALEXANDER AGASSIZ MEDAL, OCEANOGRAPHY

Recipients of the Carty Medal

CARTY, JOHN J., 1932
 WILSON, EDMUND BEECHER, 1936
 BRAGG, SIR WILLIAM, 1939
 CONKLIN, EDWIN GRANT, 1943

HENRY DRAPER MEDAL

In 1883 a fund of \$6,000 was presented by Anna Palmer Draper in memory of her husband, an eminent astronomer. It was stipulated that the medal be presented to any person in the United States of America or

elsewhere who shall make an original investigation in astronomical physics of sufficient importance and benefit to science to merit such recognition. It was further stipulated that the medal shall not be presented more frequently, on the average, than once in two years, that the investigation for which it is awarded shall be made known to the public, and that the work shall have been completed or published since the time of the last preceding award.

It was also provided that if the income of



JOHN J. CARTY MEDAL, FUNDAMENTAL SCIENCE

the fund, now amounting to \$10,000, shall exceed the amount necessary for striking the medal, the surplus shall be used in such manner as shall be selected by the Academy in aid of investigations in astronomical physics by citizens of the United States.

Recipients of the Draper Medal

LANGLEY, S. P., 1886
 PICKERING, E. C., 1888
 ROWLAND, H. A., 1890
 VOGEL, H. K., 1893
 KEELER, J. E., 1899
 HUGGINS, SIR WILLIAM, 1901
 HALE, GEORGE E., 1904

DANIEL GIRAUD ELLIOT MEDAL

In 1917 Miss Margaret Henderson Elliot gave \$8,000 to found a medal and honorarium for the most meritorious work in zoology or paleontology published each year. Thus she carried out a testamentary provision in the will of her father, Daniel Giraud Elliot. The medal, together with an accompanying diploma and any unexpended balance of income for the year, was to be awarded annually.

The obverse of the medal bears a portrait bust of Daniel Giraud Elliot; the reverse symbolizes the field of the award. The ob-



HENRY DRAPER MEDAL, ASTRONOMICAL PHYSICS

CAMPBELL, W. W., 1906
 ABBOT, C. G., 1910
 DESLANDRES, H., 1913
 STEBBINS, JOEL, 1915
 MICHELSON, A. A., 1916
 ADAMS, W. S., 1918
 FABRY, CHARLES, 1919
 FOWLER, ALFRED, 1920
 ZEEMAN, PIETER, 1921
 RUSSELL, H. N., 1922
 EDDINGTON, SIR ARTHUR S., 1924
 SHAPLEY, HARLOW, 1926
 WRIGHT, WILLIAM H., 1928
 CANNON, ANNIE JUMP, 1931
 SLIPHER, V. M., 1932
 PLASKETT, JOHN STANLEY, 1934
 MEES, C. E. KENNETH, 1936
 WOOD, ROBERT WILLIAMS, 1940
 BOWEN, IRA SPRAGUE, 1942

ject in the center of the reverse is a fossil tree trunk, surmounted by a butterfly and entwined by a snake. At the bottom is a sea shell immersed in waves, perhaps to show in a conventionalized way the beginning of life in the sea, from which, it has been said, all life came.

Recipients of the Elliot Medal

CHAPMAN, F. M., 1917
 BEEBE, WILLIAM, 1918
 RIDGWAY, ROBERT, 1919
 ABEL, OTHENIO, 1920
 DEAN, BASHFORD, 1921
 WHEELER, WILLIAM MORTON, 1922
 CANU, FERDINAND, 1923
 BREUIL, HENRI, 1924



DANIEL GIRAUD ELLIOT MEDAL, ZOOLOGY AND PALEONTOLOGY

WILSON, EDMUND B., 1925
 STENSIÖ, ERIK A.: SON, 1927
 SETON, ERNEST THOMPSON, 1928
 OSBORN, HENRY FAIRFIELD, 1929
 COGHILL, GEORGE ELLETT, 1930
 BLACK, DAVIDSON, 1931
 CHAPIN, JAMES P., 1932
 LULL, RICHARD SWANN, 1933
 PAINTER, THEOPHILUS SHICKEL, 1934
 COLBERT, EDWIN H., 1935
 MURPHY, ROBERT CUSHMAN, 1936

PUBLIC WELFARE MEDAL

The Marcellus Hartley Fund of \$1,200 was established in 1913 by Mrs. Helen Hartley

Jenkins in honor of her father, Marcellus Hartley, for the founding of a medal to be awarded by the National Academy of Sciences for eminence in the application of science to the public welfare—in these words:

Patriotism and justice alike demand that certain public services involving the application of science should receive a conspicuous recognition at the hands of the National Academy of Sciences.

It is the purpose of the Public Welfare Medal to mark the appreciation of the National Academy for eminent services to the public, performed without a view to great monetary gains and by methods which, in the opinion of the Academy, are truly scientific.



PUBLIC WELFARE MEDAL, APPLIED SCIENCE

On the obverse of the medal is the figure of Archimedes with one foot in space and the other foot on his helmet. He is straining with both hands on a lever pressing against the universe, which is shown as a segment of a sphere. The whole design gives the sculptor's conception of the application of science to the public welfare. The quotation in Greek is the celebrated saying of Archimedes: "Give me where I may stand and I will move the world." On the segment of the sphere are the symbols of Taurus and Leo, together with a cluster of stars.

\$10,000 was established by his wife, Sarah Julia Smith, in his memory. It was stated that the medal may be awarded to any person in the United States or elsewhere who shall make an original investigation of meteoric bodies of sufficient importance and benefit to science to merit such recognition.

The Latin inscription about the bust of J. Lawrence Smith gives the years of his birth and death, 1818-1883. On the obverse is a laurel wreath arranged as a crown. The Latin reads: For fruitful research in meteoric bodies.



J. LAWRENCE SMITH MEDAL, METEORIC BODIES

Recipients of the Welfare Medal

GOETHALS, G. W., 1914
 GORGAS, W. C., 1914
 ABBE, CLEVELAND, 1916
 PINCHOT, GIFFORD, 1916
 STRATTON, S. W., 1917
 HOOVER, HERBERT, 1920
 STILES, C. W., 1921
 CHAPIN, CHARLES V., 1928
 MATHER, STEPHEN TYNG, 1930
 ROSE, WICKLIFFE, 1931
 PARK, WILLIAM HALLOCK, 1932
 FAIRCHILD, DAVID, 1933
 VOLLMER, AUGUST, 1934
 RUSSELL, F. F., 1935
 CUMMING, HUGH S., 1935
 WHITNEY, WILLIS RODNEY, 1937
 HOOVER, JOHN EDGAR, 1939
 ROCKEFELLER, JOHN DAVISON, 1943

J. LAWRENCE SMITH MEDAL

In 1885 the J. Lawrence Smith Fund of

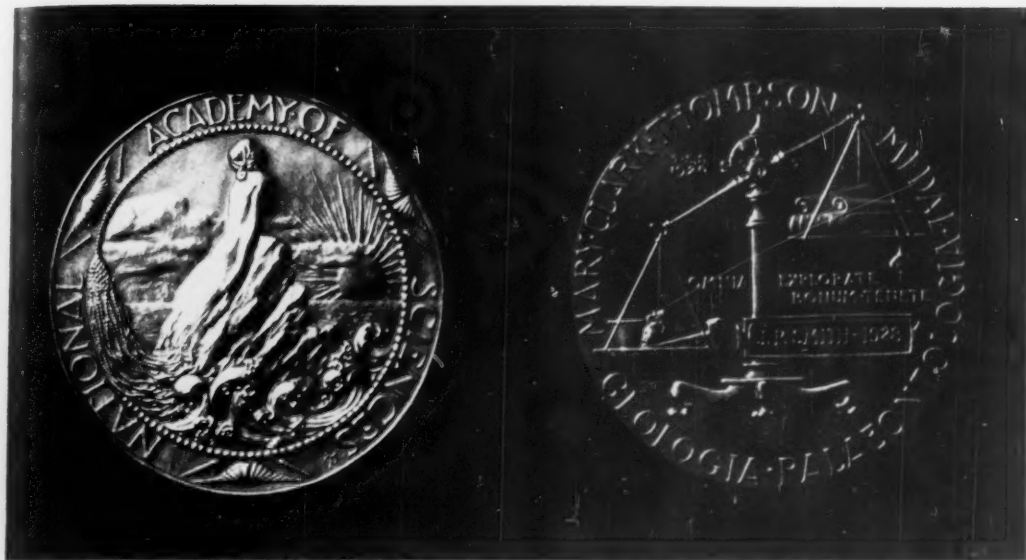
Recipients of the Smith Medal

NEWTON, H. A., 1888
 MERRILL, GEORGE P., 1922

MARY CLARK THOMPSON MEDAL

The Mary Clark Thompson Fund of \$10,000 was established in 1919 to honor the most important services to geology and paleontology. Mrs. Thompson became interested in the establishment of this fund through John Mason Clarke, who informed her that no great reward was available at that time for extraordinary contributions to geology or paleontology.

The obverse of the medal shows the sculptor's conception of geological and biological origins. The churning waves denote the sea; the rocks, upheaved in an anticlinal position from the sea, symbolize the birth of the



MARY CLARK THOMPSON MEDAL, GEOLOGY AND PALEONTOLOGY

world. The commotion extends to the atmosphere, creating clouds. Topping all is life, depicted by the nude figure of a woman looking toward the sun, which gives light to the new world for the future.

The reverse of the medal depicts a balance in which ore, crucible, and hammer outweigh the knowledge of the world in the form of manuscript and book. The legend reads: Explore everything; hold fast to the good. On the edge of the medal (not shown in the

illustration) are pressed a conventional pattern of lines enclosing the words: *Virtute et Constantia* (Courage and Perseverance).

Recipients of the Thompson Medal

WALCOTT, CHARLES DOOLITTLE, 1921
 MARGERIE, EMMANUEL DE, 1923
 CLARKE, JOHN MASON, 1925
 SMITH, JAMES PERRIN, 1928
 SCOTT, WILLIAM BERRYMAN, 1930
 ULRICH, EDWARD OSCAR, 1930
 WHITE, DAVID, 1931
 BATHER, FRANCIS ARTHUR, 1932



CHARLES DOOLITTLE WALCOTT MEDAL, PRE-CAMBRIAN LIFE



JAMES CRAIG WATSON MEDAL, ASTRONOMY

SCHUCHERT, CHARLES, 1934
 GRABAU, AMADEUS WILLIAM, 1936
 WATSON, D. W. S., 1941
 WOODWARD, SIR ARTHUR SMITH, 1942
 SIMPSON, G. G., 1943

CHARLES DOOLITTLE WALCOTT MEDAL

The Charles Doolittle Walcott Fund of \$5,000 was established in 1928 to encourage and reward individual achievement in advancing our knowledge of Pre-Cambrian or Cambrian life in any part of the world. It provides for the award of medals and honoraria to persons whose published researches, explorations, and discoveries in Pre-Cambrian or Cambrian life are worthy of the highest recognition. The awards shall be made without respect to nation, race, sex, or academic degree, on the recommendation of a board of five members, known as the Charles Doolittle Walcott Trust Fund Board, composed as follows: One ex-officio member, who shall be the Secretary of the Smithsonian Institution; two members eminent in the paleontology of early Paleozoic formations, one member to be appointed by the Institut de France and one by the Royal Society of London (each of these organizations should at all times have one representative on the board); two members distinguished in Paleozoic paleontology, to be appointed by the president and council of the

National Academy of Sciences of the United States of America.

This medal is bronze, and it was stipulated that if bronze were not available, any other inexpensive metal could be used because the honorarium is the feature of this award. On the reverse of the medal is a trilobite.

Recipients of the Walcott Medal

WHITE, DAVID, 1934
 WESTERGAARD, A. H., 1939

JAMES CRAIG WATSON MEDAL

The James Craig Watson Fund of \$25,000 was the first medal fund established under the National Academy of Sciences, in 1874. It has been used not only to provide a medal and honorarium for the recognition of outstanding astronomical research but also to promote astronomical science by supporting research and publication of results.

Recipients of the Watson Medal

GOULD, B. A., 1887
 SCHOENFELD, ED., 1889
 AUWERS, ARTHUR, 1891
 CHANDLER, S. C., 1894
 GILL, SIR DAVID, 1899
 KAPTEYN, J. C., 1913
 LEUSCHNER, A. O., 1915
 CHARLIER, C. V. L., 1924
 DE SITTER, WILLEM, 1929
 BROWN, ERNEST WILLIAM, 1936

TELEGRAPHS AND TELEGRAMS IN REVOLUTIONARY FRANCE*

By DUANE KOENIG

FROM time immemorial men have sought to communicate their ideas rapidly over vast distances. To this end they have experimented with devices ranging from the pigeon post to the pony express. One of the first of the modern inventions for quick correspondence between widely separated points was the optical, or aerial, telegraph. This was the work of Claude Chappe, a French engineer, assisted by his four brothers, Ignace, Pierre, René, and Abraham.

Claude Chappe was born at Brûlon, now in the Sarthe department, in 1763. He inherited from his uncle, a celebrated eighteenth century astronomer and traveler, the abbé Jean Chappe d'Auteroche (1722-1769), his passion for science and his indefatigable ardor for work. Early in life he applied himself to physics and mathematics and by the age of twenty was contributing articles to learned scientific periodicals. In 1790 he became interested in the problem of signaling friends who lived several miles away from his home. Adapting an idea of Guillaume Amontons, a scientist who lived at the end of the seventeenth century, Chappe developed machines which he called telegraphs; these were capable of making recognizable signs by means of dials and pendulums. They worked so well that Chappe was able to offer a demonstration for the officials of the municipality of Parcé in the Sarthe. In the presence of these functionaries on March 2 and 3, 1791, Chappe transmitted accurately and in a matter of minutes, messages from Parcé to Brûlon, a distance of more than a dozen miles. Having been given sworn affidavits attesting his experiments, Chappe set out to seek the support of the government for the erection of a telegraph line.

Shortly thereafter his older brother, Ignace Urbain Jean, was elected a deputy to

* The manuscript of this article was thoroughly documented by the author, but his citations were deleted at the request of the editors. Those who wish to know the sources of information and of illustrations should write to the author.

the Legislative Assembly at Paris. Probably through Ignace's influence, Claude was able to address that body on March 24, 1792, and inform it that he with the help of his brothers had built machines which could signal with such speed that if telegraph lines were set up the Assembly could send messages to any of France's frontiers and receive replies during a single afternoon's sitting. He submitted the affidavits of the Parcé officials as evidence of his contentions. The Assembly listened to Chappe and admitted him to the honors of the meeting. As for the matter of building a telegraph line, that was referred to the Assembly's committee of public instruction.

The Legislative Assembly expired in the turbulent days of September, 1792, without having taken any action on the telegraph. Accordingly, on October 9 following, the inventor laid before the newly elected National Convention a petition for consideration of his discovery. The National Convention accepted the petition and referred it to the committees of war and marine.

The Chappe brothers had to face not only legislative indifference but also public antipathy to their experiments. During the latter part of 1791 they obtained permission to make demonstrations at Paris and place their telegraph apparatus on one of the pavilions in the enclosure of the *Étoile*. Their machine was pulled down one night shortly after its completion by persons unknown, and it was so demolished as to be of no further use. A few months later a telegraph station was set up in the LePeltier Saint-Fargeau park at Belleville. The burghers of Belleville apparently believed that attempts were being made to communicate with the Austrians and Prussians, for a mob collected in the park and burned the telegraph to the ground. Only the warnings of friends kept the Chappes away from the scene and possible mob violence.

To make sure that further undertakings



CLAUDE CHAPPE, 1763-1805
INVENTOR OF THE OPTICAL SEMAPHORE TELEGRAPH.

would not be destroyed by the fury of the populace, Claude Chappe sent a letter on October 15, 1792, to the Convention, asking that he be authorized officially to rebuild his instruments at Belleville. When the letter was read by the secretary of the National Convention, the Deputy Rabaut de Saint-Étienne suggested that the petition be turned over to the committee of public instruction. The Convention so ordered.

It was not until April 1, 1793, that a representative of the committee of public instruction, Gilbert Romme, rose to the tribune of the Convention and spoke on behalf of the Chappe brothers. Romme pointed out that several systems of communication had been presented to the government, but that Citizen Chappe's was the only one which seemed to merit any attention. He described the Sarthe experiments and suggested that before approving the construction of any lengthy telegraph lines, the Convention appropriate 6,000 francs from the general funds of the war department to determine the workability of the telegraph. The deputy

then presented a project of law to this effect which was approved by the Convention. Five days later the committee of public instruction suggested that the Deputies Joseph Lakanal and Pierre Claude François Daumon be appointed to observe and report on the functioning of the new stations. This proposal was accepted.

That public opinion continued skeptical of the telegraph is patent from the fact that on July 2, 1793, Lakanal reported on Chappe's progress and offered the Convention a bill ordering the mayors of the communes where telegraphs were being erected, to prevent damage from being done to the machines. This decree was forthwith voted. With the legislative appropriation the Chappe brothers constructed three telegraph stations, one on the old location in the LePeltier Saint-Fargeau park at Belleville, a second on the heights of Écouen, and a third at Saint-Martin-du-Tertre.

As perfected, their telegraph consisted of a post 30 feet high, with a movable cross-piece, or regulator, attached at the top. The regulator was 14 feet long, 13 inches wide, and $1\frac{1}{2}$ to 2 inches thick. At each end of the crossbar was an indicator 6 feet long, 1 foot wide and 1 inch thick. Steel rods with lead counterweights were attached to the bases of the indicators to balance them. The two indicators and the regulator were connected by a system of pulleys to the base of the post so that they could be moved to any desired position. For visibility, the machine was painted black.

The apparatus did not spell out words in the fashion of its successor, the electric telegraph. Each sign made represented either a word or phrase, or the number of a word or phrase in the table of signals. This reduced the number of signals necessary for sending any message. The regulator could take any one of four major positions: horizontal, vertical, 45 degree tilt to the right, 45 degree tilt to the left. The indicators were capable of being used in any of seven different positions, each 45 degrees from the next. The only position not used was that of the indicator being extended straight out as a prolongation of the regulator. This signal could not be seen distinctly. Hence the telegraph could make 196 different signals. To further

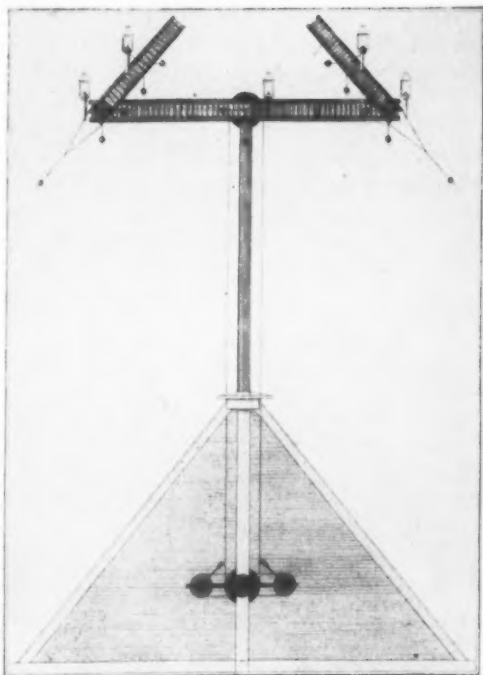
simplify matters, the levers at the base of the machine which operated the crossbar and arms always took in the signaling the same positions as the regulator and indicators.

An innovation in the communication was that, instead of sending the entire message from one station to the next, Chappe planned to send his messages one letter, word, or phrase at a time down the entire line. Thus station *A* would send the first signal. As soon as the agent at station *B* could see through his telescope the sign made by *A* and move the levers of his telegraph to the correct position, the signal would be flashed to station *C*. While station *C* would be transmitting the signal on to *D*, the first station would be in the process of sending the second signal. Like waves the signals would follow one another down the line. Experience showed that if signals were transmitted faster than three a minute, errors became inevitable.

Chappe and his brothers realized that the entire system could never be stronger than its weakest link. An inattentive agent might make mistakes which would take time for correction, or by his absence from duty delay transmission for hours. Once the telegraph was established, agents were paid about 25 sous a day, and deductions were made from their pay for every minute of tardiness or for lack of attention. Ignace Chappe said that as far as possible the telegraphers should be "simple men without intrigue."

An ex-consul, Léon Delaunay, who was experienced in the ciphers and codes of diplomacy, assisted the Chappes in the preparation of their signals. Of the dispatch signals 98 were devised for the handling of messages and 98 others for the regulation and policing of the line. These latter were necessary to indicate attention, the direction the signals would move down the line, beginning or end of a message, interruption of a dispatch for a new one, cancellation of the original dispatch, difficulties on account of weather, failure of equipment, or absence of agents. And each station had its own signal to locate it if breakdowns occurred.

On July 12, 1793, before the representatives of the committee of public instruction and several scholars and artists, the first telegraph line was demonstrated. Daunou took up his place at the Belleville station, while

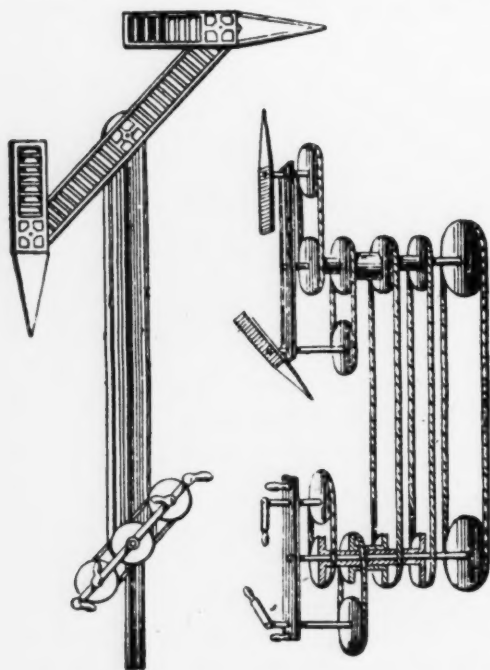


THE CHAPPE TELEGRAPH
EQUIPPED WITH LAMPS FOR SIGNALING AT NIGHT.

Lakanal and a Citizen Arbogast went to Saint-Martin-du-Tertre. At 4:26 p.m., activity signals were made and in eleven minutes Daunou was able to transmit to Lakanal, almost a score of miles away, the message: "Daunou has arrived here. He announces that the National Convention has just authorized his committee of general security to put seals on the papers of the deputies." It took only nine minutes for Lakanal to reply, "The inhabitants of this beautiful region are worthy of liberty by their respect for the National Convention and its laws." Successful communication was continued for some time until the Écouen station signaled that it was unable to dispatch further messages.

Lakanal made a formal report to the Convention on August 14 following. He stressed particularly the accuracy of the telegraph and emphasized the fact that only people knowing the codes, which could be changed at any time, would be able to intercept messages. The most secret dispatches might be sent with only the first and last stations on the line understanding the meaning of the

ciphers. The committee of public instruction recommended that a sum of 58,400 francs be appropriated for the construction of a line from Paris north to Lille, on the frontier of the Austrian Netherlands. This line would consist of sixteen stations, averaging about 6,000 francs each in cost. With certain economies the total amount necessary might be reduced from 96,000 to 58,400 francs. This project of law passed the Convention, and in recognition of his work



THE CHAPPE TELEGRAPH

ILLUSTRATING THE SYSTEM OF LEVERS AND PULLEYS USED TO OPERATE THE REGULATOR AND INDICATORS.

Claude Chappe was granted the titles of telegraph engineer and engineering lieutenant in the army. He and his brothers Ignace and Pierre François were named administrators of the telegraph line.

The choice of locations for stations required great care, because faulty sites would affect the whole line. After stations were set up, they sometimes had to be relocated and the direction of the line changed. Almost a year was required before the proper route could be determined and the telegraph instruments erected between Paris and Lille. The stations were finally completed by mid-

summer of 1794. The first news sent from Lille to Paris was that of General Scherer's recapture of LeQuesnoy from the Austrians and Prussians on August 15, 1794. On August 17, the Deputy Bertrand Barère de Vieuzac announced the victory and added: "We seize upon this occasion to speak to you of a new establishment made under the auspices of the National Convention, of a machine by means of which the news of the recapture of LeQuesnoy was brought to Paris, an hour after our garrison re-entered the town." He then reviewed the history of the telegraph in almost panegyric tones: "Modern peoples by printing, gunpowder, the compass and by the language of telegraph signs, have made vanish the greatest obstacles which have opposed the civilization of men, and made possible their union in great republics. It is thus that the arts and sciences serve liberty."

A fortnight later the telegraph brought the news of the recapture of Condé. The Convention received word at 1 p.m. on September 1 and immediately sent to Lille a message of congratulations and a decree changing the name of Condé to Nord-Libre. Before the end of the afternoon session, the Convention had received from Lille an acknowledgment of the message.

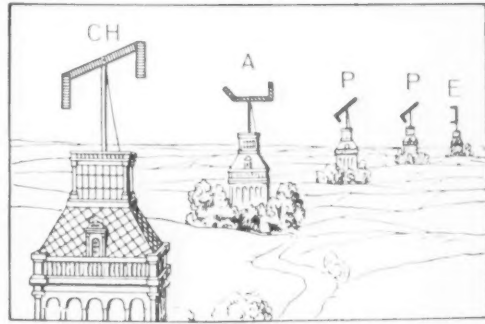
The success of the Paris-Lille line brought a flood of enthusiasm and ideas for new lines and new types of telegraphs. In 1795 the committee of public safety began the construction of a telegraph line from Paris to Landau. To call for help in the event of an attack on the Thermidorian Convention by the Paris mob, the first station of the Landau line was located on the pavillion of *Unité* of the Tuileries near the national alarm bell. A mechanic, a harbormaster, and a mathematics professor collaborated in the construction of a signaling machine called the "vigigraph" and obtained money from the Directory to build a line from Paris to Le-Havre. The vigigraph consisted of a ladder raised into the air with two fixed crosspieces. A movable disk on one side of the ladder and a movable regulator on the other side made signaling possible by their relation to each other. One of these instruments was erected on the tower of the Church of Saint-Roch at Paris. It remained there unused for a long

time before being removed to gather dust in the storerooms of the telegraph administration building. No other stations of the projected vigigraph line were ever built.

In 1797 Chappe extended a line from Paris to Strasbourg and located the final station on the Strasbourg cathedral. This chain of stations began operations the next year, reporting the news from the Germanies brought to Strasbourg by the Rastatt courier. The line was lengthened to Huningue in 1799. The Lille telegraph was carried to Dunkerque in 1798 and at the same time a line was built from Paris to Brest via Saint-Malo. Another addition to the Paris-Lille network came in 1803 with a branch to Brussels and one to Boulogne. Other extensions were to Anvers and Flushing in 1809 and to Amsterdam in 1810. In 1797 the Directory authorized a line to the south of France, but actually stations were only built as far as Dijon. It remained for Bonaparte to order telegraphic communication between Paris and Milan, the capital of his Italian kingdom. Five years later, in 1810, Milan and Venice and shortly afterwards, Mantua, were connected by telegraph.

The Directory built a few mobile telegraphs for the army until the funds allotted for these units ran out. Bonaparte took up the idea and at the time of the war with Russia attached Abraham Chappe to his staff to direct the use of the telegraph for military purposes. The use of the semaphore telegraph, which under favorable conditions could send a message from Paris to Venice in half a dozen hours, contrasted very favorably with a signal flag system Napoleon ordered in 1809 to communicate between his military headquarters at Vienna and Strasbourg. Bonaparte apparently believed that the mere stationing of men at regular intervals with signal flags would suffice to send messages. Created without regard to scientific location of stations, this line was never able to transmit messages successfully.

Claude Chappe found the path of the inventor a thorny one. On every side he met rivals claiming to have invented telegraphs and seeking a share of the credit for the invention. A watchmaker named Bréguet and his associate Bétancourt so discouraged Chappe by their quarrels with him over the

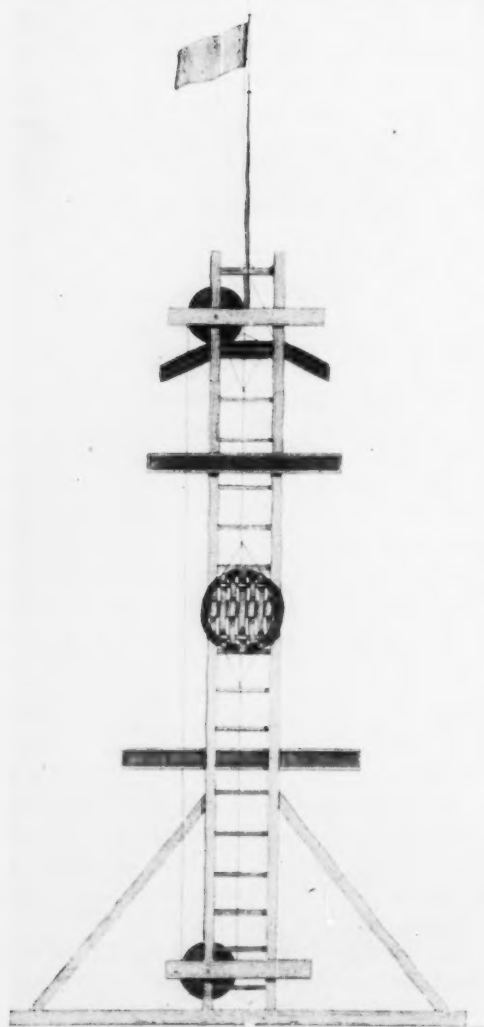


THE TELEGRAPH STATIONS
PLACED ON HILLS EIGHT TO TWELVE MILES APART.

priority of his ideas that he committed suicide on January 23, 1805. Direction of the telegraph continued in the family after Chappe's death. When Louis XVIII was restored to the throne of France in 1814, he granted Ignace, Pierre, and Abraham the rank of chevaliers of the Legion of Honor. These favors from the hands of the Bourbon were sufficient to give currency to the rumors during the Hundred Days that the Chappes were under arrest. To clarify the situation, the brothers felt obliged to write the editor of the official *Gazette Nationale ou le Moniteur Universel* to point out that while a military post had been established in the offices of the telegraph administration, it was to protect the telegraph and not to arrest the Chappes. The letter was published on March 17, 1815.

The Bourbons constructed numerous telegraph lines. By the time the electric telegraph was introduced in 1844, there were some 534 optical telegraph stations and more than 3,000 miles of line serving 29 of France's largest cities and towns. In 1816 a line was constructed from Paris to Calais. A line from Lyons to Toulon began operation at the end of 1821 and replaced the old line of Napoleon's to southern France. The capital and Bordeaux were connected in 1823, via Orléans, Poitiers and Angoulême. The same year also saw Bayonne brought into telegraphic contact with Paris and by 1828 a line from Avignon to Perpignan via Nîmes and Montpellier was in action.

From the opening of the Lille line in 1794 and for five years thereafter, the telegraph administration was controlled by the engineering division of the war ministry. From



THE VIGIGRAPH

AN IMPRACTICAL TELEGRAPH, REVOLUTIONARY PERIOD.

1799 to 1830 it was under the minister of the interior. In 1823 King Louis XVIII retired Ignace Chappe on a pension of 4,255 francs and Pierre on an income of 2,252 francs. The younger brothers, René and Abraham, remained in charge of the telegraph thereafter. The eldest Chappe died on January 26, 1829, at Paris. Two days after his death his three surviving brothers felt forced to deny publicly that the monarchy had allowed him to die destitute. From 1830 until May 28, 1831, the telegraph was in the public works administration; then it went back to the interior ministry. The Chamber of

Deputies passed a bill on March 14, 1837, and the Chamber of Peers on April 17 following, which made the telegraph a government monopoly and provided fines of 1,000 to 10,000 francs for any person or persons transmitting telegraph signals without government authorization. The last report of a new optical telegraph line was that of the Paris-Agen system which was put in operation in August, 1844, and could send dispatches of medium length to the capital city in fifteen minutes. The year 1844 also saw the inauguration of the Paris-Rouen electric telegraph line. The telegraph stations in France were never co-ordinated into a really effective network which could carry orders from the Paris government to the capitals of all of the departments in a matter of minutes. Indeed, it was not until 1823 that the telegraph was reported as being used to bring news from the capital to the provinces and handle other than army or diplomatic matters.

Night telegraphy was much more difficult than day telegraphy and the results obtained were much less satisfactory. As early as October 18, 1794, the National Convention received suggestions from a citizen for using the telegraph at night. The Chappe brothers hung lanterns 8 inches wide and 12 inches high to the arms and crosspiece of their machine. There were two lamps on each indicator and one on the regulator. For three years the telegraph on the dome of the Louvre was equipped with such lamps. When Napoleon was plotting his invasion of England and wanted night communication with Boulogne, a telegraph with only one indicator was devised. The indicator and regulator were hung with three lanterns 16 inches in diameter equipped with parabolic reflectors. Although incapable of the number of signals the day telegraph could give, it was workable.

In 1822 a day and night telegraph was constructed between Paris and Bordeaux by Rear Admiral Saint-Haoun. The heir to the Bourbon throne, the Count of Artois, was interested in the project and on October 23, 1822, was present at a demonstration of correspondence between Montmartre and Orléans. The experiment worked to the full satisfaction of Monsieur. This episode brought a

sharp letter to the *Moniteur* from Ignace Chappe who denounced Saint-Haoun's undertaking as "a very imperfect attempt," and added: "It has been 29 years that the telegraph has actually been in use now, taking not more than a minute per word to transmit messages more than a hundred leagues. . . . When the government will desire it, we will use the telegraph with the same speed, *night* as well as day."

The fact that the night telegraph never worked very well constantly brought forth new ideas for night signaling. The inventor Jules Guyot proposed that the Chappe telegraph be adapted for night signaling by hanging two white lanterns at the ends of the regulator and a green lantern at the end of each indicator. He also conceived a night telegraph using two hydrogen lanterns. This device was never established practically. In 1831 one Ferrier de Tourettes went to England to promote a two-lamp telegraph which he said would be able to work with stations eighteen miles apart. No system of night telegraphy ever came into general use, and it was for the Morse invention to provide instantaneous night communication.

Although the scope of this paper is the development of the optical telegraph in France, it should be observed that this means of communication was tried elsewhere with varying success. In 1794 the Swedish scientist Endelerantz invented a telegraph consisting of a block of ten rectangular panels, each panel turning on an axis. By opening and closing these panels in various combinations, he was able to signal intelligibly. He made his first public demonstrations between Drottningholm and Stockholm on October 30, 1794. Two years later a short line of three of these telegraphs was put in use in the Aland Islands.

The British used a modification of the Endelerantz system, a telegraph with six panels. In 1796-97, London and Dover, London and Sheerness, and London and Plymouth were connected. The Admiralty building in London was the headquarters for the telegraph network. A year later it was reported that the British were making portable telegraphs for use with forces engaged in putting down the Irish rebels.

The Chappe telegraph was also very popular outside of France. A line was projected in 1801 from Basle to Augsburg by the French military authorities, and in 1802 a line was built in Denmark. The British in India constructed a line from Calcutta to Chunar, a distance of 336 miles. Messages could be sent from one end of the line to the other in twelve minutes. The next year the energetic Egyptian Sultan Mohammed Ali built a line of nineteen stations between Alexandria and Cairo which could carry signals between the two cities in four minutes.

The Prussian government spent 170,000 thalers on a line of telegraphs from Berlin to the Rhenish provinces, via Potsdam, Magdeburg, Cologne, Coblenz, and Trier. The Prussian telegraph had six semaphore arms; when it was put in operation in 1832, it was under the control of the war ministry and handled only government messages. Not to be outdone, the Czar Nicholas I of Russia ordered a series of telegraph towers between St. Petersburg and Warsaw. There were 220 stations, each requiring six operators. Thus more than 1,320 men were needed to carry the first message on April 12, 1839, which announced that the Czarina had just recovered from a serious indisposition. From 1844 to 1859 an aerial telegraph existed in Algeria.

The opening of the Paris-Rouen electric telegraph line in 1844 brought the Chappe system to an end. The optical telegraph lasted fifty years and during this period provided France with a faster and more dependable means of signaling than had ever been used anywhere previously. Perhaps the best summation of the work of the inventor Claude Chappe was the statement in the *Moniteur* on January 28, 1805, which announced his death: "People rightly say that the signaling art existed long before him. What must be added to be just and impartial, is that he made of this art an application, so simple, so methodical, so sure and so universally adopted, that he can be regarded as an inventor." On the centennial of the telegraph in 1893, a statue to Claude Chappe was erected in Paris at the intersection of the boulevards Saint-Germain and Respail and the rue du Bac.

A. A. MICHELSON VISITS IMMANUEL KANT

By A. BOYAJIAN

In the ages when people believed in ghosts inhabiting everything, there was no conflict between intelligence and matter, none between purposeful action and physical necessity. But ever since ghosts have been driven out of things by a reign of law in nature, intelligence and purposeful action have been steadily crowded out of the physical world by matter and physical necessity; and the human soul, as the last of the ghosts, has been reduced to an insecure, furtive existence.

What does science say about the matter?

What does philosophy?

Although science does not openly teach anything about this specific subject, yet it insinuates enough. Philosophy does discuss it freely but obscurely, and few people ever hear about it. We will review some of these insinuations and teachings, and attempt to evaluate them. For properly evaluating opinions, we will want to know the competence of the source of the opinion and the validity of the method by which the opinion has been arrived at.

All sciences are systems of thought constructed out of certain assumptions held together by a framework of reasoning. This is very clear in the case of mathematics, which starts with certain assumptions called postulates and works up to a series of conclusions called theorems. By the authority of a tradition of long standing, which may be called mathematical license (after poetic license), postulates are privileged things and may not be questioned except on grounds of inconsistency. For a long time they were even called axioms. Evidently, mathematics is an exact science only in the steps of reasoning from postulate to theorem; it can be real or unreal depending on one's choice of postulates.

The physical sciences are subject to greater discipline in their premises but less so in their reasoning from postulate to theorem. The postulates of the physicist are his data, and these may not be assumed freely under

any kind of license but must be obtained by certain traditional methods of experiment and observation. Data so obtained may not be questioned and are supposed to assure "reality," but they open the door wide to contradictory postulates. Evidently, a system of thought based on data which are under no obligation to be consistent among themselves cannot be exact in the mathematical sense but must win temporary acceptance by making the best sense out of the mass of disorganized raw material, and perhaps by occasionally foreshadowing — predicting — things that can be verified by test.

The usual pattern of any progress in the physical sciences is therefore (a) a new set of data at variance with previous ideas, (b) a new hypothesis, (c) a theory, (d) predictions and further tests, (e) a temporary law of nature. The common laws of the physical sciences must be acknowledged as tentative: think of what happened to Newton's "law" of gravitation, the individual "laws" of conservation of mass and conservation of energy, and Maxwell's "laws" of electricity and magnetism in the Lilliputian world of electrons and protons. Tentative or not, these laws had the far-reaching result of establishing a belief in physical necessity which is of paramount importance for our subject. Physics teaches us that the universe is made up of electrons, protons, neutrons, and quanta obeying certain laws, some pretty well known, others to be clarified further, but, whatever the exact formula may be, the picture is one of blind (unconscious) matter tossed about by blind (unpurposeful) forces in obedience to blind (meaningless) physical laws.

The physicist carefully avoids the embarrassing philosophical implications of these theories with respect to man, God and immortality, and other philosophical questions, but these have to be faced sometime or other.

In a brain consisting of electrons, protons, neutrons, and quanta, how is consciousness

possible? For such a brain, how is purposeful action possible? Also, how is knowledge of things in themselves possible? Does the brain secrete thought as the liver secretes bile? In the functioning of the brain, do the electrons, etc., obey the same laws as elsewhere? If so, are freedom and purposeful action a delusion? Does thought have no effect at all on the physicochemical processes in the brain?

The rank materialist (he calls himself a determinist) takes the position that consciousness is an "epiphenomenon"—a surface phenomenon—an appearance, a foam, on the stream of the physical processes in the brain, with no more effect on these processes than the man in the moon has on the moon's movements. A ludicrous aspect of this extreme attitude is that the judge is denying his own reality. Descartes turned the tables on these extremists by his famous syllogism, "I think, therefore I am." It might have been still stronger if he had said, "I doubt, therefore I am." Few scientists profess such materialistic views nowadays. Most people feel that this picture of the universe depicted by science is inadequate. How can it be improved without becoming unscientific?

The oldest theory of escape from scientific fatalism is that man consists of matter and of mind as two independent realities working together in the brain. The matter in the brain obeys natural laws, but in the complex organic reactions of the brain there are conditions of neutral or unstable equilibrium on which occasions the mind can control the direction of the processes one way or another without having to expend any physical energy which, of course, it does not have. So the freedom of the mind and the necessity of physical processes in the brain are reconciled.

To draw an analogy, the mind controls the brain and the body as relays do in electrical and mechanical systems. Control by relays contemplates changing the course of physical events without contributing any matter or energy to the phenomena under control, and yet the theory of relays is not inconsistent with the law of conservation of energy or the physical necessity that governs the electrical and mechanical phenomena.

To draw another analogy, catalysts divert chemical reactions into directions which would not otherwise be followed, and yet catalysts contribute neither material nor energy to the reaction product, and the control they exercise is not considered as in conflict with the laws of conservation of energy and matter or with the law of physical necessity.

This line of thought has been given further encouragement by Heisenberg's Principle of Uncertainty about the position and velocity of electrons. This theory says that when either the position or the velocity of an electron is determined, the other is merely a matter of probability, never of certainty; and that this situation arises not from our ignorance of the facts, but from our knowledge that the facts themselves exist in nature only as probabilities. Some scientists have interpreted this as meaning that nature is not really controlled by the law of cause and effect, as matter in the gross seems to be; that natural laws are only *probable* laws, highly probable in the gross, less and less so in the minute.

A serious objection to this theory of escape is that the relationship of the mental process, which is continuous, to the physical brain process, which also is continuous, must be a continuous one. An occasional interaction between mind and matter at times of unstable equilibrium is not acceptable.

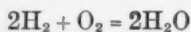
As to the so-called Principle of Uncertainty, the applicability of the law of probability to the electrons cannot exempt them from the law of physical necessity any more than the many other phenomena in nature to which the law of probability is applied.

Another serious objection is that it does not explain how a nonmaterial thing like the mind can react on a nonmental thing as matter. After all, relays and catalysts are material things and constitute a portion of the larger material system which they form in combination with what they control, and the whole system follows physical necessity without a break, without a surprise, without an intrinsic uncertainty. Moreover, catalysts do enter temporarily into the reactions which they control, and they do so by virtue of their surface energy.

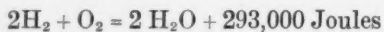
A further objection is that it does not explain how the future outcome of a physical process can be predicted by a purely mental process. If mind and matter are separate realities, it must be a miracle that the consequences of physical necessity and the conclusions of logical necessity should correspond to each other.

I think we will agree that this is the old ghost theory in new dress restricted to the brain, scientific in appearance but only a pseudoscience.

It has been attempted to avoid the major difficulty of the foregoing theory by boldly assuming that mind is something like energy and is involved in all physical phenomena—in the rusting of a nail as well as in the brain process that represents philosophical speculation. A number of scientist-philosophers, including Steinmetz, have held this view. According to it, a chemical reaction, for example, is determined by three factors, not two: matter, energy, and mind. In the early days of chemistry, the matter involved in a reaction was considered as the main thing, the accompanying energy was treated as an incidental by-product, as if it had no effect on the reaction, and so it was left out of the equation. Accordingly, the reaction of hydrogen and oxygen to form water was written as

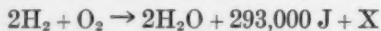


We recognize today, however, that energy relations are a controlling factor in reactions, and the foregoing equation is very inadequate, in fact, incorrect, the complete correct equation being



This equation satisfies the law of conservation of mass plus energy, whereas the old one would not, because $2\text{H}_2\text{O}$ is a little lighter than $(2\text{H}_2 + \text{O}_2)$ at the same temperature.

But is the new equation really complete? The suggestion has been made that it is not, and that some day we shall add to the right-hand member of the equation a third term representing a mental factor:



the X in this equation being the mind-stuff that is necessary to balance the equation.

Furthermore, it has been suggested that, just as the long-ignored energy term has come to be recognized as an important determiner of reactions, so in time we shall come to realize that the mental factor X is just as important as either one of the other two factors in determining the progress of a chemical reaction.

If that is true, one may wonder how we have been able to get along in chemistry so far without the X component. The answer is given that, just as the energy phenomenon is very intense and important in some reactions, and weak in others, so the mental element is imperceptible in inorganic reactions, very faint in germs, and very conspicuous in the brain. Also, just as the energy factor is never absent in a reaction, no matter how weak, so the mental stuff is never completely absent in the humblest reaction, down to the rusting of a nail.

If this view is true, we may well inquire also whether the law of conservation applies to the mental-stuff just as to matter and energy; and whether there is a conversion factor for the transformation of matter to mind-stuff and energy to mind-stuff, and vice versa, like Einstein's conversion factor for the transformation of matter into energy and of energy into matter.

This is a typical monistic philosophy. Its great merit lies in the fact that it unifies reality: instead of having three kinds of basic stuff—matter, energy, and mind—we have one basic reality, capable of assuming three different forms convertible into each other. A friend reviewing this manuscript remarked that perhaps the law of relativity holds also to the extent that what appears to one observer as mind may appear to others partially as energy and to still others partially as matter, depending on their co-ordinate systems!

The speculation is clever and intriguing, but it has its weaknesses. One of them is that, while it sounds like a scientific theory, it lacks scientific evidence. Another weakness of it is that, from a metaphysical point of view, it is naïve.

But what is metaphysics?

Just as modern physical science is a disciplined form of empirical knowledge, so mod-

ern metaphysics is a disciplined form of philosophic thought. Philosophic thought (of which metaphysics is a subdivision) is frequently referred to as "speculative" thought. That characterization was undoubtedly true about most of the pre-Kantian philosophic thought and is true also about a great deal of the modern, but philosophic thought does not necessarily have to be mere speculation. Kant asks in his *Critique of Pure Reason* if a science of metaphysics is not possible, and then proceeds to develop one—successfully, too, in the opinion of many qualified judges, for instance, Herbert Spencer, who incorporated a good deal of Kantian philosophy into his *First Principles*. Herbert Spencer's endorsement is particularly significant for us because he was a qualified scientist as well as a qualified philosopher—a rare combination. In the same sense in which we generally date modern science from the publication of Bacon's *Novum Organum* (1620), we may date modern metaphysics from the publication of this book of Immanuel Kant in 1781.

Well, what does this "science" of metaphysics concern itself with? What does it teach?

It concerns itself with a critical examination of the soundness of the foundations of the other sciences, with the truth—or reality, or meaning—of the data obtained by the scientific method. As to what it teaches, let us arrange an interview between Immanuel Kant and Albert A. Michelson—between one of the keenest philosophic thinkers and one of the ablest scientific experimenters—and see how their arguments might clarify this matter for us. Kant never traveled very far from his native city, so we may take Michelson to him on the occasion of a posthumous tour through Europe.

IN KANT'S STUDY

Michelson. Great privilege to meet you, Herr Professor. My associates in the psychology department tell me that you are the most profound philosopher.

Kant. I surely am pleased to meet a great physicist-astronomer. Your measurement of the diameter of Betelgeuse interested me a great deal. I am fond of astronomy, and you may be

familiar with my nebular hypothesis. I have said more than once: "Two things fill me with awe: the starry heavens above and the moral law within."

M. You surely made a great hit with the astronomers with that saying of yours. It sounds like raising astronomy to the rank of the moral law. I wish somebody with prestige like yours had said something like that about physics—my real profession. I do not pretend to be an astronomer, even though I did make that measurement you mentioned. My most important work has been the determination of the velocity of the earth through the ether. The result has convulsed the scientific world. Einstein says it is the end of the Newtonian natural philosophy and the beginning of a new one he calls the Theory of Relativity. Of course, you are familiar with these developments. What do you think of them, Herr Professor?

K. I did see some reference to those things, but I must confess that I did not bother to look into the matter—I have so much to write. Furthermore, although I do not doubt the scientific significance of your measurements, yet I know "a priori" that they cannot have any philosophical-metaphysical significance whatever. The sciences are based on experiment, but philosophy—to be more specific, metaphysics, my specialty—cannot be based on experiment, nor can it be disproved by any set of experiments. Professionally, I am not interested in specific scientific theories (my interest in astronomy is only a matter of hobby).

I am interested in science, its foundations, the validity of its method, the possibility (or impossibility) of knowledge of reality, the meaning of the data of experience, the significance of moral law, immortality, the meaning of God, and like fundamental questions. I studied theology but soon discovered that its method—not necessarily its conclusions but its method—was very unsatisfactory, and so I developed my transcendental metaphysics.

M. Your comments intrigue me a great deal, Professor Kant. You say philosophy is not based on experience or experiment? Is it all rank speculation then? Any knowledge, to deserve the name, must be based on experiment and measurement: all else is fancy, if not folly.

K. Would you call mathematics fancy or folly? And yet it is not an experimental science. Euclid's theorem that the sum of the angles of a

triangle is 180 degrees is not based on mensuration, is it?

M. The way it is proven ordinarily, it is not; but if I were teaching geometry, I would get the pupils to cut out paper triangles, snip the corners and set them side by side to see that they add up to 180 degrees.

Kant smiles for the first time in his life.

K. My dear Professor, your pupils, as mathematicians, would make excellent experimental physicists like yourself. They surely would not add anything to our knowledge of mathematics and would ruin our confidence in mathematical generalizations. The most that can be proved about the angles of a triangle by physical measurement is that they add up to $180 \pm k\sigma$ degrees, σ being the standard deviation of the errors of measurement, and k a factor of conservatism based on the degree of probability we insist on. That kind of procedure could arouse a strong suspicion that the true answer is 180 degrees, but the suspicion would forever remain only a suspicion, never a certainty.

M. I think that it is the way it ought to be; there should always remain a little doubt or uncertainty. Newton gave the law of gravitation as $M'M''/D^2$ because various applications of the formula that he made agreed with it within the error of his data. But now, based on my interferometer tests, Mr. Einstein says that the true law is $(M'M''/D^2)(1 + \epsilon)$, ϵ being a very small fraction depending on certain things. If Newton had been more modest and had frankly kept in his formula the term of uncertainty of his data, he would have been considered a greater physicist today.

K. Professor Michelson, are you not mixing up physics and mathematics as if their methods were alike? The method of mathematical generalization is fundamentally different from that of the natural sciences, which fact makes one absolute, the other tentative. My nebular theory is surely tentative, subject to change in the light of more adequate data; but both mathematics and my transcendental philosophy are "apodictic"—not based on experiment and unshakable by any experiment.

M. All right, Professor Kant, I shall cite examples from mathematics to show you how some of these "apodictic" conclusions of mathematics have been proven to be wrong. A highly-esteemed associate of mine in our mathematics department

was telling me recently that Euclid's axiom about parallel lines, as never intersecting, is not necessarily true; that the theorem about the angles of a triangle is not necessarily true; that even the axiom about the whole being greater than any of its parts is not necessarily true. I am sure the man is not crazy.

K. I shall take your word for your associate. What did he say is true?

M. He said that different kinds of space are possible, each with a different geometry, and he classified them as follows: (A) Real Spaces, including (a) flat, or Euclidean, space, (b) parabolic space, and (c) hyperbolic space; (B) Complex Spaces, including (a) one dimension imaginary, (b) two dimensions imaginary, and (c) three dimensions imaginary; and (C) N-dimensional Spaces.

Each one of the complex spaces and N-dimensional spaces also can be flat, parabolic, or hyperbolic. Einstein has hinted that our space is 4-dimensional, with time as one of the dimensions and imaginary at that. I must confess that I do not have the mathematical head to understand all these things, but I am inclined to accept the verdict of these geniuses as against Euclid.

K. Good. Did your friend say whether the geometries of these various kinds of spaces have been worked up at all?

M. Oh, yes. He said that each space is identified by a tensor K which represents the "curvature" of the space (don't ask me what that means); and if K is given, then they know the entire geometry of that space. He also showed me a book by Julian Coolidge entitled *Complex Geometry* in which one dimension is imaginary. It was full of theorems far above my head.

K. Were the theorems in that *Complex Geometry* proven experimentally?

M. Well, of course not. They were typical mathematical proofs.

K. Would you say that those theorems were provable by experiment, such as mensuration?

M. I suppose not, seeing that the space of that geometry was imaginary and not our kind: it had nothing to do with time.

K. You believe the theorems were true?

M. I am willing to give Julian Coolidge the benefit of the doubt.

K. Do you also believe that the geometrical theorems about those other kinds of spaces are true?

M. I am willing to take them on faith, because I do not understand them.

K. And they are not provable by experiment?

M. None, except those about our own real space.

K. I thought you were going to prove to me how experiment has overruled mathematical conclusions. Instead of doing that, you have told me how mathematics has progressed and how the recent mathematical generalizations have broadened the little field of geometry which Euclid had developed. You have done also something very significant for my philosophy and very damaging to your original thesis: you have admitted that it is possible to have "a priori" knowledge, that is, knowledge "before experience"—without experiment or observation—about spaces that do not even exist and which therefore could not possibly be objects of experience or experiment.

Metaphysics does not concern itself with specific scientific theorems. It is immaterial for my purpose whether the angles of a triangle add up to 179° or 180° , or 181° , or $180^\circ + F(k)$: it is enough if the function $F(k)$ is knowable without experiment. Metaphysics concerns itself with fundamental questions like these:

(a) Are there "a priori" judgments, that is, knowledge not dependent on experience for its truth (even though it may be occasioned by experience) and therefore not disprovable by experiment?

(b) How is such a thing possible?

(c) What implication does that have with regard to reality and God?

(d) How are freedom and moral responsibility possible in a world of physical necessity, and what significance does that have about reality, immortality, and God?

I have discussed the first three questions in detail in my book entitled "*Critique of Pure Reason*," and the fourth in detail in "*Critique of Practical Reason*."

In the first book I have shown—but I should not bother you with these things, Professor Michelson, seeing you are on a vacation trip.

M. Do tell me about them, Professor Kant. You have aroused my interest, and you talk clearly and interestingly like a scientist, instead of enigmatically and oracularly like the rest of the philosophers.

K. Thank you, Professor Michelson.

All knowledge can be classified in two basic

groups, namely, (a) "a priori," or non-experimental; and (b) "a posteriori," or experimental. Most of our knowledge is of course a mixture of the two.

Examples of the first are: Time has neither beginning nor end; space has no boundaries; all phenomena are the necessary consequences of the immediately preceding set of phenomena and the cause of the succeeding ones; all phenomena take place in space and time; the sum of the angles of every *rectilinear* triangle equals 180 degrees; those of a *curvilinear* triangle with curvature K , $180 \text{ degrees} + F(K)$, the function F being as defined in the textbooks; etc. Note that these judgments need no experiment and cannot be disproved by experiment, that they are absolute and universal judgments, and that we cannot conceive of their opposites.

As examples of the second group: Today Professor Michelson visited Immanuel Kant; the diameter of Betelgeuse is so many miles; the wave-length of yellow light is 5800 Angstrom units, etc. Now, such judgments can be had only after the event, or by experiment; they are specific, not universal, judgments; and their opposites are equally conceivable. Am I clear and reasonable so far, Professor?

M. Yes.

K. Now, Professor Michelson, you remember Aaron's defense in the case of the golden calf. He said that people gave him their gold ornaments, he threw them into the fire, and out came a calf. Now I believe it is generally suspected that Aaron poured the molten gold into a mold; that, otherwise, he would not have gotten what he did. You agree with me?

M. Surely.

K. Let us consider the merits of conceiving of our minds as a highly complex and perfectly transparent and invisible mold into which experience throws a great miscellany of raw materials. In course of time, a miscellany of molded articles will be in evidence. Certain judgments about these articles will be really about the mold itself, while others will relate strictly to the raw materials.

The judgments about the *forms* will belong to the mold; and those about the *substance*, to the raw material. While our judgments about the substances can be only after the event and by observation, still, if the mold were conscious of itself as we are, it could tell with absolute cer-

tainty and universality, before the event, the alternative forms which any raw material thrown in will necessarily have to take, depending on the portal through which it enters the mold. Inasmuch as the forms in which the molded articles exist are the forms imposed on them by the mold, those forms are not the intrinsic properties of those materials in the mines, and the mold may never know the condition of the raw materials in the mines. Thus, much that it discovers by studying the molded articles will be information about its own self—what it does to the raw materials.

You see what I am driving at? Speaking figuratively, our perceptions, conceptions, etc., are all molded-and-assembled articles; our minds, the complex mold and assembly man. What we call knowledge or science is material automatically molded by the mind and set in a logical array. All of the universal elements in that exhibit are the properties of the mind itself, not of some other reality. The theorems about triangles and circles, about space and time, about causality, etc., are theorems about the "categories" of the mind. They are true or valid in the sense that they are the preconditions of what we call experience and knowledge. Any experience—for instance your interferometer measurements—are bound to take the forms that they do in the act of being observed, in the act of being calculated and reasoned. Thus it is that knowledge of non-existing non-Euclidean spaces is possible; for if something corresponding to them should come into existence and enter our experience, it would automatically and inexorably become cast by our minds, in the acts of observation, perception, and conception, into the very forms that the mathematicians of non-Euclidean geometries say our minds demand. You see, such knowledge is not really knowledge of a far-away fact, or of the future, but knowledge of our own mental makeup, knowledge of how we will react under certain circumstances.

Knowledge is necessarily something essentially mental. We grant that it is occasioned by the impact, on our minds, of a nonmental reality; but to identify the sound with the horn, the shadow with the man, the phenomena with the noumena (the reality-in-itself) is naïve. Knowledge of reality is not a duplicate of reality, but its token, and may not be any more like reality than a hundred-mark bill is like a hundred-mark

gold piece of which it is a token. "The-thing-in-itself" is unknowable.

Does what I said make sense, Professor Michelson, or does it sound ridiculous to you?

M. Putting a reasonable interpretation on what you have said, I think I can agree with you, Professor Kant. Let me say it in my own words.

All knowledge can be divided into two classes: subjective and objective. We can dogmatize on subjective matters without physical experiment, but objective judgments must be based on observation of facts. Abstractions, like space and time, and the mathematical theories of the abstract spaces, are all subjective and therefore do not need experiment and perhaps may not be disproved by physical experiment. Color sensations and our feelings evoked by musical timbre are subjective qualities; however, they are evoked by objective facts which in themselves are harmonic phenomena in space and time. Matter is a substance—a reality-in-itself, a "noumenon," I believe you called it—and matter in space-and-time is a true objective fact, regardless of the presence or absence of an observer. And we may not know exactly what matter is. Is this not true? If not, what is the matter with it?

K. Phenomena can be distinguished as subjective and objective, but that distinction is not the same thing as that between phenomenon and noumenon. A subjective phenomenon can be true, and an objective phenomenon can be false or falsely evaluated. The metaphysical distinction is between appearance and reality-in-itself. I am talking about so-called objective facts. But the claim of an objective fact to identity with a reality-in-itself needs proof.

Every new glimpse of matter that we get turns out to be another *appearance*, and the reality-in-itself constantly eludes us. To be seen, reality must "appear" to us, and all that we can get out of an appearance is an appearance to which our perceptive faculties can respond.

A voltmeter either will not see a phenomenon we wish to observe, or if it does, it will measure it as a voltage! You can get an indication of temperature on a voltmeter, but this is made possible only when some provision is made to make the temperature appear like voltage to the voltmeter. The instrument may never know what it is that is being represented as a voltage! Let us consider your measurement of Betelgeuse. What did it look like in your interferometer?

M. I suppose you want me to say, "a series of light and dark bands of light," which it was, of course.

K. Precisely. To an interferometer, an object either does not exist, or exists as bands of light and darkness. To the ear a phenomenon either does not exist or exists as sound. But what you hear in the telephone is not the reality-in-the-wire: the receiver and the ear have modified it to make it perceivable by the mind.

In all detection and measurement by instruments, in all perception by the senses, the very act of perceiving includes as an essential operation the processing of the phenomenon into a form suitable for perception by the mind. The eye may tell the ear that what appeared to it as sound was really nothing but some undulations in air; and touch and taste and smell may say that there was nothing. The chief intelligence officer, studying these reports, may "reason" an explanation that reconciles these reports, but the *explanation* is only a system of percepts and concepts. Is the thing-in-itself a thought—something mental? Betelgeuse is an objective fact (as contrasted to subjective things), it is a *scientific* reality, but it is not that *philosophic* reality-in-itself that causes the senses and the reasoning to elaborate the scientific picture of it.

As a crude analogy, our minds may be thought of as a system of indicating instruments (perceptive faculties or senses) and integrating instruments (conceptive faculties). We may be sure of our indications and integrations, but never of the realities-in-themselves that occasion those indications and integrations.

M. We may admit that not all of our scientific theories and pictures are final truths, but is not at least some of our scientific knowledge the reality-in-itself, Professor?

K. What, for instance?

M. That the constellation of Orion is a system of particles arranged in the known fashion out in space, roughly so far away from us.

K. An essential element of that picture is space. If space is a reality-in-itself, independent of our perceptive faculties, what you say would be reasonable. But space is not the substance but the form of a percept. If space were an intrinsic property of reality, independent of perception, our knowledge of it would be exclusively "a posteriori," empirical; and then pure geometry would be impossible. But if space is a mental

condition imposed on perceptions to make perception possible, then pure—non-experimental, "a priori"—geometry would be possible, as we believe it is. In that case, however, an object in space ceases to be a reality-in-itself and has to be rated merely as a *representation* of reality.

Science has an objective validity but only as a representation, nothing more; and the representation must never be confused with "the reality-in-itself." All discussions of reality have of necessity to be done in terms of words, in terms of thoughts; and thus, no matter how much we talk or reason, we miss the reality-in-itself, unless the latter is identical with the words or the thoughts.

Scientific reality is a construction—a projection—of the mind. Of course, it is not an illusion or fiction of the imagination, but neither is it the reality that the philosophically naïve believe it is.

M. Is not roundness an intrinsic property of the apple; or do we impose it on the apple?

K. That the apple shall appear to us as having *some* shape is imposed on the apple by the nature of our perceptive faculty; but that the apple should take *that* shape and not some other is the secret of the noumenon that underlies the perception of an apple. The noumenon is not something in space, inasmuch as space is a form of perception and conception; and, therefore, it is altogether futile to try to draw a one-to-one correspondence between the molecules of the apple and their noumena, and thus of the shape of the apple and that of the noumenon of the apple. Plurality, correspondence, etc., are mental concepts, and thus apply only to phenomena, not to noumena.

M. Professor Kant, what is the objection to saying that our mental pictures represent reality the way a paper photograph represents a person in the flesh?

K. Both the photograph and its object, being phenomena, can be subjected to identical scientific observation and their important correspondences and differences determined. But that cannot be done with our scientific picture of reality and the reality-in-itself. What if the correspondence should turn out to be like that of the musical composition, "The Blue Danube," to the Danube River? Undoubtedly, to the composer that music represented the river. Yet we would hardly accept a musical representation of a river to be of the same nature as that of a photograph and its

object. The scientific object we call river is in its turn a visual representation of a non-visual something which we may call X. The analogy is a very crude one, of course, and we must not push it too far.

M. Do you mean, Professor Kant, that the reality underlying the physical universe is not necessarily three-dimensional in itself, but that we see it so because our perceptive faculty is such; that it is perfectly possible that minds having a different perceptive faculty may see reality as four-dimensional or imaginary, or something else?

K. Precisely; and the multi-dimensional geometries tell us some of the relationships that we would discover among such perceptions if we had them. Our reasoning faculties are marvelous in so transcending our perceptive faculties. Our perceptive limitations are also necessarily those of our perceivable actions, and therefore we cannot circumvent nature or ourselves by an occult sojourn into the fourth dimension but must follow the three-dimensional scientific path to the mastery of phenomena.

M. I think you must concede that at least physical time is a reality independent of the observer. There must be a past, present, and future to noumena, just as much as to us, because the sequence of their action on our minds determines the sequence of the phenomena.

K. The bars of a symphony emanating from a phonograph have a time sequence to our ears, and yet our eyes tell us that the entire symphony, from the first bar to the last, exists on the record *simultaneously*, spread out in a geometrical pattern. Evidently, the perceptive faculty (the phonograph) converts the visual space sequence into an auditory time sequence. How can we know what it is in the noumena that our minds represent as a time sequence, seeing that noumena do not even have a space sequence in themselves? Furthermore, if time cannot be reversed, if the record cannot be played backward, the limitation might be inherent in the phonograph and not necessarily in the record or the noumena.

M. May I ask, Professor Kant, what conclusions you draw from all this about God Almighty?

K. God is a requirement of the mind—an "ideal" of the mind in my transcendental philosophy. A rational view of the universe without God in it is impossible. That, however, merely proves that the God so conceived of is a necessary condi-

tion of thinking and not necessarily the photographic image of something far away. As a reality-in-itself, God transcends scientific knowledge. Theologians sometimes speak of the Supreme Being as the First Cause, but that is very poor language; because as time has no beginning, there can be no first anything, and therefore no first cause either. Furthermore, a cause in a time sequence, no matter what its number, the first one just as much as the last one, would be only a phenomenon and therefore not God. God must be looked for in the realm of the spaceless and the timeless—the realm of the noumena—and that we cannot know.

M. Your philosophy is a bit discouraging, and, if you'll pardon me, a bit depressing to me, Professor Kant. It sounds like a philosophy of Can't.

K. Kant's philosophy is not all can't, even though there is a good deal of that in it. The positive aspects of it are sublime. However, we must first recognize the limitations of scientific knowledge, then we may the better evaluate the redeeming elements in my philosophy.

M. Do tell me something about those redeeming elements, Professor Kant.

K. Let me explain to you, then, the havoc that the English school of philosophers played with science and religion, and how my philosophy has saved both.

Imbued with the Baconian scientific spirit, and as a reaction from theological dogma, Locke scrutinized the facts of psychology the way scientists were scrutinizing the facts of physics, and in his *Essay on Human Understanding* he developed the thesis that all our knowledge comes from the senses in course of experience and that "there is nothing in the mind except what was first in the senses." At birth our minds are a blank sheet—a *tabula rasa*—and experience writes on it a host of facts through the senses. Sensations accumulate in memory, and memory begets ideas we call knowledge: we are not born with any innate ideas implanted in us by God as the theologians teach.

Then Bishop Berkeley developed the idea that the physical world is merely an appearance and that there is no matter or external reality corresponding to it.

Then David Hume, the brilliant skeptic, in his *Treatise on Human Nature*, picked up where Locke had left off and developed the doctrine that (a) all our scientific generalizations are in-

ferences from limited observations and therefore can never have an absolute validity. The only foundation for the belief in cause and effect is the observed uniformity in nature. Such limited observations, however, cannot prove definitely that the same cause must always have the same effect. (b) As to mathematical judgments, he taught that they are true only because they are tautological, that is, they affirm in the predicate what was already implied in the subject by definition; $2 \times 2 = 4$ is not new knowledge, but saying the same thing in two different ways.

With matter and its equivalent gone, with any dependable basis for scientific generalizations gone, and mathematics reduced to tautology, science was threatened to its foundations. That alarmed me and spurred me to philosophy. You see how my analysis saves science. The mind is not a passive tablet on which experience writes what it pleases. Matter, as we know it, is an appearance but not an apparition. Phenomena are molded by our perceptive faculties, and therefore experience cannot escape our perceptual forms. Scientific laws like cause-and-effect are relationships to which all phenomena become automatically subjected when they submit to observation by the mind. Knowledge is as much a product of the mind as of the noumena that act on the mind, and therefore the mind can lay down the law to phenomena in certain respects just as the noumena do in certain other respects. It is true that we are not born with knowledge of scientific generalizations and mathematical theorems: these develop as our nature in course of experience, just as a seed exposed to the soil and sun develops into plant and flower according to its own nature. But to say that there is nothing in the flower that was not first in the soil betrays abysmal ignorance of what the nature of the plant does to the material absorbed from the soil in which it grows.

The unsophisticated believe that one cannot abstract a rabbit from a hat unless there is one in there first. Well, there will be one in there first, if there is one in the sleeve of the magician first of all. Our minds are no mean magicians.

As to mathematics, it is not a matter of toying with definitions, but it is replete with *synthetic judgments*, with genuine new knowledge; and these have a controlling validity derived from the mind, in that no phenomena that submit to observation by the mind can escape the mathematical

relationships required of them and imposed on them by the mind. If mathematics were nothing but playing with definitions, masters of language would make the best mathematicians. How contrary are the facts! A system of mathematics may be said to be implicit in its postulates but only in the sense that the latter define what portion of the vast field of mathematics may be considered consistently under a given title.

So much for what my philosophy has done to put science on an unassailable foundation in a new light. Let us review now what it has done for man's soul.

Just as the Bishop disposed of matter, so Hume disposed of the soul. To paraphrase him, he said: "I am aware of nothing but a succession of sensations. I find no mind except as the collection of this stream of sensations. I find no soul. These are theological dogmas with no foundation." So David (Hume) believed that he disposed of the theological Goliaths of freedom of the will, immortality, and God.

Before I indicate what my philosophy has done for the soul of man, will you tell me, Professor Michelson, how science solves the problem of the freedom of the will?

M. Science does not solve it. Physicists dodge it by confining themselves strictly to physics, and the other scientists avoid it the same way. Psychologists avoid it by dodging the physical aspect. If forced to face the issue, some scientists would say, "There is no freedom"; and others, including myself, would say, "We don't know."

K. Assume that science does not know it now; is it likely that it will ever know it?

M. I don't know. What do you think?

K. I don't have to conjecture about the matter. I know that science will never know it, because it cannot know it—with the methods it uses. Might as well hope to find iron filings with an electrified piece of amber, or lycopodium dust with a magnet. It is like trying to find God by going far enough back in time to catch the First Cause.

M. How does your transcendental philosophy solve the problem, Professor Kant?

K. This way. Space and time, and cause and effect, are mental forms imposed on phenomena; and, therefore, no phenomenon or datum of science, present or future, can escape physical necessity. What goes on in the brain, analyzed to the minutest detail, will be found to be the

effect of the preceding physicochemical state and the cause of the succeeding physicochemical state. The more minute the analysis, the more so will be the conclusion. You will never discover consciousness, moral freedom, etc., in the brain by studying it with an interferometer or any other scientific instrument or method, any more than you can discover what the musician calls "sound" by studying the vibrations in the air or the corresponding impulses in the auditory nerves. A person born deaf could become an acoustical physicist and yet never know sound. When you hear sound, you understand the musician.

Coming back to our problem, man has two aspects: one, as a phenomenon; the other, as a noumenon. As a phenomenon, he is bound to appear just as subject to cause and effect as any other phenomenon; but as a noumenon he is beyond the limitations that he himself imposes on phenomena. He is directly conscious of himself—something that could never be discovered by scientific observation in the absence of "apperception" (self-awareness in perception). Furthermore, when we say, "We should not do this; we ought to do that," it is the noumenon breaking through phenomena. We are then face to face with the reality-in-itself. The moral law exposes the artificiality of the pretty system that the cognitive faculties of the mind set up so as to make possible a scientific representation of reality and the physical mode of reaction to reality. All our actions, in so far as they enter the world of phenomena, observable by scientific methods, automatically become phenomena and stand in cause-and-effect relationships to other phenomena. That is their phenomenal-scientific aspect. But the conscience makes it clear to us that in their noumenal aspect our actions are free and spontaneous.

Physical necessity and moral or purposeful action are contradictory, but the contradiction is not an attribute of reality; it is what I call one of the "antinomies" to which the mind itself gives rise, and the solution of which is found in the mind itself—by a recognition of what the perceptive and cognitive faculties of the mind do to phenomena and how in moral action we get beyond them.

You can see why two things fill me with awe—the starry heavens above and the moral law within. In the cosmic spectacle, I am aware of one of the grandest products of the cognitive

(scientific) faculties of the mind; in the moral law, the "categorical imperative" of the conscience—to act as if the maxim of our action were to become by our will a universal law of nature—I am aware of being face to face with that which transcends space and time—the ultimate, the self-sufficient, the Supreme Being. There is our clue to immortality. Immortality does not mean to live on and on in time; it means that, as noumena, we realize a nontemporal existence; it means passing from a scientific framework into a noumenal framework.

In the moral principle we have a glimpse of the noumenon that is ourselves in the most intimate sense. So, you see, my philosophy is not discouraging, but highly inspiring.

M. Professor Kant, I think I begin to get a little understanding of your transcendental philosophy, and I like it very much. I never heard anything like that before. If I may presume on your patience a little longer, I should like to say it in my own words, and have you correct me if I go wrong.

K. I will be highly pleased to see how far I succeeded in conveying my philosophic thoughts to a hard-headed experimental physicist.

M. The problem is how to reconcile physical necessity and moral or purposeful action. Also, how to reconcile physicochemical processes with intelligence.

When we consider what is going on in a head, if it is our head it looks to us like a pure mental process. We are aware of no brain, no matter, no physicochemical action, no cause and effect. If it is somebody else's head, it looks to us like a bony skull, containing a brain involving a highly complex organic chemistry, subject to cause and effect. Comparing the behavior of the owner of that head with our behavior, we may infer that the fellow must be intelligent like ourselves (though, of course, not necessarily to the same high degree), and that, like us, he must be aware of himself as a thinking, feeling person, not as a physicochemical system. We are likely to infer also that we must have a brain inside our skull and that our thinking process must be associated with it in some fashion.

That we are a thinking, feeling something is a matter of direct knowledge for us, while the idea that we have a brain and that our thinking is its function is scientific elaboration out of certain sense perceptions. Even if a surgeon should open

our skull and let us see our brain in the mirror, no amount of scientific study would enable us to recognize it as either ourselves or any of the thoughts that may be on our minds at the time. Granting that with sufficient study we should be able to determine with certainty definite correspondence between certain brain conditions and certain thoughts or emotions, that is far from finding thought or emotion in the brain. Correspondence would not mean identity. The more we study the brain process, the more bio-chemistry we shall discover, but we shall get no nearer to the discovery of thought and emotion by such a study—these must forever lie beyond detection by physicochemical methods. Not only that, but we may become increasingly convinced that the reactions going on in the brain are completely accountable by physicochemical forces, just as completely and inexorably as the rusting of a nail; and that, while we are aware of being conscious beings ourselves, it is scientifically possible (even though perhaps morally reprehensible) to treat others as absolute automatons.

We have inside information about ourselves as being intelligent agents whose behavior is purposeful action. Even when we are foolish, the intent is yet intelligent, and even when we accomplish the opposite of what we purposed, we still did act with a purpose; and it is enough for our present purpose that the behavior be of a conscious and purposeful nature, whether of a high or of a low order. However, looking at ourselves and our behavior through the eyes of outsiders, or through our own eyes but from the outside, we find that we are a complex system of organic chemicals capable of very intricate behavior, but still completely controlled by physicochemical forces, by cause and effect. There is the contradiction.

Which one shall we say is true?

We answer, "Both, from different points of view"; and having so answered, we are under obligation to reconcile the contradiction. The object of our study is something of which the internal aspect is that of an intelligent purposeful agent; the external aspect, that of something conditioned by physicochemical forces. Apparently, the progress of the changes in this reality can be traced equally well in either psychological terms or physicochemical terms. In practice, in some cases one is easier; in other cases, the other. For instance, theoretically the rusting of a nail

could be treated in psychological terms, but perhaps we do not know yet how to do it in a worthwhile manner, and would prefer chemical terms. Also, theoretically, it is possible to describe the behavior of people—of ourselves—as those of a physicochemical system, but how hopeless in our present state of knowledge!

In the study of the living tissues, we find it necessary to carry along both views side by side and jump from one to the other as convenience demands. To study the human body in purely physicochemical terms, avoiding all reference to function and purpose, is a hopeless undertaking, just as hopeless as to study it as pure psychology, with no reference to the physics and chemistry of what is going on in the body.

The contradiction arises from, and is resolved in, the fact that reality has two aspects; an internal one and an external one. The internal aspect is that of an intelligent purposeful agent; the external one, that of a physicochemical system. Either view is theoretically workable to the exclusion of the other. They appear contradictory but really they are not; and that is the reason why it is possible in practice to carry along both views, applying one or the other as it may prove more convenient. Maybe someday we shall have the psychology of a rusting nail . . . and the chemistry of faith, hope, and charity. Because our knowledge is so incomplete—wholly external (scientific) of most things, and mostly internal (conscious) about ourselves—the two views appear to us incompatible in the abstract and indispensable in the concrete.

Professor Kant, we have a remarkable parallel to this in the present state of our knowledge of electrons.

Generally we treat the electrons as *particles*, having a certain mass and charge and subject to electrical forces and to elastic impact; but we find also that, in certain situations, an electron must be treated as if it were a *wave-train* of certain definite frequency, subject to the interference phenomena of waves, as opposed to the impact phenomena of elastic particles. Of course, it is puzzling now how an electron can be both a particle and a wave train at the same time, and, of course, we expect that this puzzle will be explainable in time; but whether explained or not, we are convinced now that certain concepts, like *particle* and *wave*, that formerly were considered as incompatible with each other and inapplicable

to one and the same thing, do apply to one and the same electron.

In our present state of knowledge, matter and physical necessity appear to us as incompatible with intelligence and purposeful action in one and the same thing, but if we are to accept the data of the physical sciences and of introspective psychology jointly, as the data of a philosophical system, then we must assume that the apparent incompatibility arises from the differences in the methods and points of view—one internal and direct, the other external and indirect—and that it remains for us to discover the code that will enable us to reconcile them and to translate one story into the other. I suppose someday a bright boy will discover the clue, maybe in the record of a Rosetta stone telling the same story word by word in both languages, that is, in both the language of matter and physical necessity and the language of intelligence and purposeful action; and, then, man, *that* will be a real "philosopher's

stone." Eh, Professor Kant? Have I caught on to your transcendental philosophy?

K. You are doing pretty well, indeed, for the first lesson in metaphysics, Professor Michelson. May I make a suggestion? Someday when you put away the interferometer for good, and decide to go out in search of that philosopher's stone, look for it first in my two books. It is there. "My chief aim in this work has been thoroughness; and I make bold to say that there is not a single metaphysical problem that does not find its solution, or at least the key to its solution, here."

M. Professor Kant, you have so aroused my interest in philosophy that I am not going to wait that long to read your books. I shall have them with me on the steamer and shall incidentally test their efficacy in disposing of seasickness as a mere phenomenon!

Adieu, Professor Kant.

K. Adieu and bon voyage, Professor Michelson. *Auf baldiges Wiedersehen.*

STARLIGHT

The light from the stars not seen by the naked eye exceeds the light of all visible stars.—H. T. STETSON.

*How bright the star-shine in this country place,
Above the topaz lanterns, moving, glowing,
That fireflies kindle over Queen Anne's Lace,
Whiting the field and hillside, billowing, blowing . . .
Here have I stood on a blue-white winter's night
When a thousand tiny prisms turned in the snow-drifts
And stars like ice shed blue and ruby light
In a jeweled revelation out of the cloud-rifts . . .
I have come here tonight with the world in the dark of the moon,
Brooding on sorrow, and desolate, near to despairing,
Weeping for soldiers, like rose-petals fallen too soon . . .
But the stars lean down; an astronomer's voice is declaring:
Oh, live not alone by the gleam of your finite discerning;
Through the spiraling stairways of heaven starlight is burning!*

—BARBARA WHITNEY

AVIATION MEDICINE IN THE ARMY

By BRIGADIER GENERAL E. G. REINARTZ

RECENTLY while on an inspection trip, it was my pleasure to be interviewed by a feature writer of one of our prominent Northwest newspapers. When she was informed that I was a flight surgeon and an exponent of aviation medicine, she said, "Oh, that is a new type of medicine of which I know nothing. It must be a very new branch of medicine." When told that I, with others, had spent more than a quarter of a century in the practice of this "new type of medicine," she was covered with confusion. This is not an unusual situation, and only too few individuals know this rapidly developing field of specialized medicine. For specialized it certainly is as it deals exclusively with the individual who has learned that relatively new art and science—flying.

Aviation medicine had its earliest beginning with Leonardo da Vinci, the famous anatomist and first developer of the helicopter.

One hears but little concerning this subject until the Montgolfier brothers sent sheep and fowl into the air to determine whether or not any ill effects occurred to living tissue by reason of ascending into the atmosphere in a balloon. Nothing having happened, they then felt it was safe for human beings to ascend, and accordingly the first flight was made in October, 1783, by an individual who was surgeon, apothecary, and superintendent of the royal museum.

The first book containing scientific data on aeronautics was written by an American, Dr. John Jeffries, in 1786. These data were presented to the Royal Society on April 14, 1785, and read before it in January, 1786. Interestingly enough, John Jeffries on his second flight, that across the English Channel, was the carrier of an air mail letter, having delivered the same to Benjamin Franklin—"the first through the air."

The first handbook of aeronautics dealt in part with the physiological aspects of ballooning, and ascents were strongly advised for those convalescent from disease. The observation made at that time was: "The

spirits are raised by the purity of the air and rest in cheerful composure. In an ascent all worries and disturbances disappear as if by magic." It was believed that this salutary effect was brought about by a change "from hot, putrid and impure to cool pure air; impregnated with the invigorating aerial acid."

In 1878, a most remarkable book was published by a Frenchman named Paul Bert. This book lay dormant for a number of years without its importance being realized. However, it has latterly been translated and has been given wide circulation because of its timeliness. The latter half of the book dealt, for the first time, with problems that are of vital importance in this age of stratosphere flying; namely, the effects of decreased barometric pressures and various phases of anoxemia.

Although the first heavier-than-air powered flight took place on December 17, 1903, the Wright brothers were discredited until 1908. Unfortunately, the importance of the conquering of this new element gradually dawned on other nations before it dawned on us. This is indicated by the fact that ten years after the discovery of heavier-than-air flight, our Government owned but two airplanes. The onset of World War I, from which we attempted so desperately to remain aloof, found us totally unprepared, and the land of the birth of the airplane entered the war "with an Air Service in its cradle and its aviation medicine in its swaddling clothes."

Dr. Theodore C. Lyster in 1914 appreciated the importance of temperamental, psychological, and physical qualifications for those who engaged in flying, and with others set up standards for the examination of flyers. This group laid the foundation of what is known as aviation medicine. General Lyster is therefore rightfully called the father of this important branch of medicine.

In October, 1917, the Medical Research Board and Medical Research Laboratory was formed and began to function. In January,

1918, the Central Medical Research Laboratory opened its doors. The work of the Laboratory increased greatly in amount as well as in importance, and rapid strides were made in the many problems with which this Laboratory was concerned.

The pioneers of aviation medicine during the last war worked on practically every problem with which we are faced today, at least to the extent of laying the basic foundation on which those of us coming after them could build. They worked on such problems as anoxia, effects of decreased barometric pressures, acceleration, and many other factors that were even then causing difficulties for the pilot although the airplane was in its operational infancy. One has but to read the literature of that period, meager though it is, to be convinced of these facts.

Those who founded the branch of science known as aviation medicine believed in the principle that those who were engaged in research should also be engaged in teaching. So it was that the School of Flight Surgeons was founded at Hazelhurst Field, Long Island, in 1919. It was also known to these founding fathers that the pilot in his newly found environment created an especial problem. This was all the more pointedly brought to their attention by the finding of the British that during the first year of World War I, 2 per cent of their losses were due to the enemy, 8 per cent to structural failure, and 90 per cent to the pilot himself and that after the institution of a service known as care of the flyer, their losses due to physical defects were reduced during the second year from 60 to 20 per cent and during the third year from 20 to 12 per cent. The comparable statistics of the present war cannot be stated for reasons of security.

The School has fostered research in aviation medicine through the years. Immediately after the last war, appropriations were drastically cut, medical personnel assigned to the Air Service was at a minimum, the research laboratory as such was closed in 1920, and yet the spark of research was kept glowing, albeit very dimly at times.

During the early twenties, the first satisfactory aerial ambulance plane was developed by a flight surgeon, Major Edward L.

Napier, M.C. In 1926, one of the most outstanding and far-reaching developments in aviation was consummated; namely, the statement of the relationship between the illusions of the senses as developed in the internal ear and the fatal spin of the airplane. This development, the medical aspects of which were reported in 1936, was the result of research by a medical officer, the then Major D. A. Myers, M.C., and a pilot, the late Capt. William C. Ocker, A.C. The technical aspects were published in 1930. In my opinion this finding is the outstanding development in all of aviation, second only to that of flying itself. Prior to the announcement of this development, no long distance flights were possible unless conditions of external objective reference obtained. It was only after the theory of so-called "blind flight" was brought to the attention of those who had the courage to believe their bank and turn indicator instead of their intuitive sense in the "seat of their pants" that the extended flights of the present day, wind and weather to the contrary, notwithstanding, became possible. It was a heart-breaking experience to indoctrinate to mechanization those who believed themselves endowed with special powers that permitted them to fly without such newfangled devices as the bank and turn indicator.

During the late twenties, while assigned to the Matériel Division of the Air Corps at Dayton, Ohio, I began experimentation in a small way on problems involving the loss of hearing in flyers, the use of ear plugs, corrective goggles, the effect of noxious gases on the pilot, and the neuropsychic aspects of the effect of flight on flying personnel. I was followed by Major Malcolm C. Grow, M.C. (now Brigadier General) who developed the first medical research laboratory of the Air Corps and was its founder and first director. A tremendous stimulus was thus given to the advancement of medical science in connection with aviation. To General Grow must go the credit for stimulating medical research not only in the Air Service of the Army but also in other laboratories. The Aero Medical Laboratory at Wright Field has thus been the forerunner of research in this important field.

During this time the School of Aviation

Medicine was engrossed with training students to select and maintain flying personnel. Nevertheless, that staff too was not idle in research, and in 1934 Major (now Colonel) N. C. Mashburn, M.C., then Director of the Department of Psychology, developed the Mashburn Complex Coordinator, which with refinements is still the psychomotor testing apparatus that gives the highest validation in the psychomotor testing battery of the Psychological Testing Program of the Army Air Forces.

With the advent of the year of limited emergency announced by the President, Congress voted more funds for all purposes, and the research program of the Army Air Forces kept pace with the tremendous development begun by those forces. Highly technical personnel became available at the same time that new aeronautical medical problems were posed. The National Research Council with its Committee on Aviation Medicine became active, and laboratories all over our country were beginning to ask how they might assist in the solution of the many problems that were then presenting themselves.

It was about this time that the School of Aviation Medicine took on added growth, and the need was felt for a research laboratory to delve specifically into the problems of the individual himself. Thus it was that the Research Laboratory of the School of Aviation Medicine was activated January 20, 1942. There were then two medical laboratories in the Army Air Forces under the jurisdiction of the Air Surgeon. As has been stated, the Aero Medical Laboratory at Dayton, Ohio, had been carrying on the principal work and now with the development of the new laboratory at the School of Aviation Medicine some division of the responsibility had to be made. Thus the laboratory at the School of Aviation Medicine deals with the individual, his selection, his mental and physical body and its reactions to the varying conditions of flight, while the Aero Medical Laboratory deals with the things one hangs on that body, in other words, the pilot in his airplane plus all of his equipment.

It will neither be possible for me to relate the outstanding contributions to aviation

medicine made by our sister service, the Navy, nor to go into the field of research so ably carried out by the many civilian agencies that are now spending much time and large sums of money on the most laudable solution of our many unanswered problems.

Since aerial warfare has become so devastating and the modern airplane flies at such unheard-of altitudes and speeds, many problems are posed at this time that were only of academic interest a few years ago.

War in the air was made less disastrous to operating personnel of aircraft by the development of the Grow "flak" suit, which has been markedly successful. This closely resembles the suit of mail worn as early as the fourth century and is donned as the combat crew prepares for its battle stations. It was simply the application of an old idea to the most modern of situations, with the saving of lives of many of our bomber personnel.

The increased range and accuracy of anti-aircraft fire has forced the airplane ever higher, necessitating certain developments that would permit man to rise above this destructive force. During the last war airplanes would hardly rise to an altitude where life was actually jeopardized by lack of oxygen. Today, however, such flights are routine daily experiences. The oxygen mask with its many improvements is now a very satisfactory product delivering 100 per cent oxygen, if needed. Increased altitudes necessitated the development of the pressurized cabin. If the enemy should be able to reach our superfortresses and puncture the pressurized cabin, explosive decompression would result. To guard against that danger, pressure breathing of oxygen was also developed.

The increased speeds of airplanes with the accompanying development of tremendous "G" forces, plus and minus, have created problems the solution of which is sought by the use of the human centrifuge. These researches are leading to the production of devices that will minimize blackout and therefore make the pilot more efficient in his rapidly executed maneuvers.

The Army has developed low pressure tanks that can be refrigerated. It is possible in these tanks to reduce the pressure to a simulated altitude to which man has never

risen and to reduce the temperature to a degree never experienced by man in the normal environment. Extremely low temperatures, which are reached in the present-day bombing missions in certain types of our planes, have necessitated the development of electrically heated flying suits because the inherent warmth of the human body and the insulating effect of dead air spaces were insufficient to maintain comfort and efficiency.

Since in this war the pilots are engaged "around the clock," it became necessary to take into consideration the flyer's ability to engage the enemy at night. The testing of night vision was carried out, and an elaborate system of training in dark adaptation was evolved. We teach our personnel to view objects off center at night at low levels of brightness and to use a scanning or roving vision so that they may see the enemy better than they could by looking at him directly. This may be termed seeing out of the corners of your eyes.

Since much of this war is being fought in the Tropics, it has become necessary to know how the drugs used in combating tropical diseases affect the ability of the pilot to fly satisfactorily and whether they have any influence on his ability to tolerate altitude. It is also important to know whether there is any relation between altitude and recrudescence of the most prevalent tropical disease. With the tremendous upswing in global flying through areas that are heavily infested with insects that transmit tropical diseases, much concern is being shown by governments lest these diseases be transported either directly or by means of vectors. Disinsectization of all airplanes passing through or coming from such areas is mandatory.

Through the years we have been indoctrinated with the concept of physical exercise for the sake of physical fitness. As a result of wartime experimentation a new and unprecedented concept has evolved—physical exercise for convalescence's sake. When a patient who has been strong and physically well becomes a casualty, his excellent physical condition quickly retrogresses. It was thought that if exercise could be employed, reconditioning of the patient would progress much more rapidly. This has proved to be

the case, especially where surgery is involved. The reconstruction program of the Air Surgeon permits men who become casualties to be rehabilitated more quickly, and it has the most far-reaching implications not only for the Army but for the civilian population as well.

In order to select the vast numbers of young men who must be trained to fly complicated and expensive airplanes, new methods of examining the prospective pilot had to be devised. The methods evolved have been eminently successful, and by far the greater proportion of those who pass the classification tests for flying become pilots. The results of these tests have validation by the pass-fail criterion in training only. Much study is now being devoted to the ultimate in military aeronautics—the question of pass-fail in combat. This brings to the foreground the will of a man to fight, the mental fortitude towards combat, the degree to which he has the killer instinct and whether or not his personality type is such as to make him flee or fight. It must be constantly kept in mind that no matter how well integrated an individual is mentally, each has his breaking point. When committed to combat, some break early, whereas others come through their battle experiences apparently unscathed. Each, however, carries with him some scars produced by the terrific emotional trauma experienced in modern aerial warfare. Much has been done and is being done to reduce the effects of these traumata. New methods of treatment have been evolved that permit the release of these emotional tensions with the result that the memory of the horrors of war is reduced to a minimum.

One of the outstanding contributions made recently in the interest of the safety of flying personnel has resulted from the study of the pathological lesions that develop as the result of rapidly applied decelerative forces when an airplane crash occurs. It has been found that typical lesions occur in the heart, great vessels, lungs, liver, spleen, and intestines. The new understanding of what happens to the human body in crashes may save many lives. Furthermore, changes in cockpit and airplane design are being made that will soften the blow of a crash.

With the tremendous increase in engine

noises and the whine of the tips of propeller blades that travel, in many instances, at speeds approaching that of sound, the assault on the pilot's ears is a matter of much concern. Added to this are the possibilities of the staccato insults due to machine gun and cannon fire, as well as the trauma produced by continual listening to the radio beam compounded by static that at times reaches such proportions as to approach the pain threshold. Much research is being performed in the solution of these problems, but success is somewhat difficult to attain, for as one reduces with ear defenders the trauma due to excessive noise, one also reduces the auditory acuity, with its attendant difficulties for the pilot.

Since time immemorial, individuals who have "gone down to the sea in ships" have become seasick. So also has illness overtaken many who travelled in trains and automobiles. With the advent of flying annoying airsickness made itself manifest. Investigations proved that many of these cases were based on factors with a psychogenic background; others have been caused by motion per se. At this time, the term 'motion sickness' is applied to those cases that have the characteristic symptoms of airsickness. Those who never become acclimatized in their new environment are therefore relieved from duty necessitating flying. It is interesting to note that individuals assigned to certain kinds of air activity are, as a class, more prone to motion sickness than are others. Considerable improvement through experimentation has been made which permits many who have been affected by motion sickness to become habituated to motion and progress to a normal, nonsymptomatic flying experience.

Flying all over the face of the globe, over all manner of terrain on aerial missions of hours' length, flying personnel are subjected

to severe eyestrain due to the brightness of the sun per se, or to the reflected light from that surface of the globe over which they happen to be flying. This called for the development of devices to safeguard the most important sense organ necessary in flying—the eye. One need but visualize the actual pain developed by sun-searching for an enemy, the dazzling whiteness of the Arctic snows, the brilliance of reflection by miles of ocean, the searing glare of flying over tremendous stretches of desert, and the devastating effects of millions of candle power of searchlights to appreciate the devastating effect on vision and the absolute need for a device to protect it.

Protective goggles had to be developed and are used not only for the purposes mentioned but also to assist in the protection of flying personnel who may be subject to "flash" burns, due to the flash ignition of gasoline fumes released from gas lines severed in combat. Goggles, too, of varying shades of color are used by flying personnel in "ready rooms" in order to prepare themselves for dark adaptation so that their night vision will be most acute should they suddenly be called for a night mission. The varying conditions enumerated pose serious problems. However, their solution, while not yet adequately accomplished, is well on the way.

A final note must be added about the Army Air Forces School of Aviation Medicine. At this School, along with the experimental work that has been conducted, teaching of flight surgeons is its principal activity. Here medical officers of the Army Air Forces are indoctrinated in all matters affecting the pilot, the environment in which he works, and the vicissitudes of that environment. They are then sent to all parts of the globe where our airmen fly and are writing an ever-increasing, glorious page in the history of aviation medicine.

ON THE RELATION OF MATHEMATICS AND PHYSICS

By R. B. LINDSAY

It is reported that the greatest scientist who ever lived on this continent once remarked: "A mathematician may say anything he pleases, but a physicist must be at least partially sane." Most physicists and probably other scientists as well heartily agree with the first part of this dictum attributed to Willard Gibbs, but some of us are beginning to have our doubts about the second part. In these wartime days the word physicist is defined to mean a person who never gets a vacation, and few people bearing this title get even a moment or two to stop and think in the midst of their incessant preoccupation with the devising of bigger and better engines of destruction. And if we add to this group those who are busily engaged in instructing people how to use these engines of destruction, or teaching the fundamentals of physics to those who will ultimately have to use them (encountering in the process more than the normal "emotional resistance" to the subject), we may well wonder whether it is any longer fair to assume that physicists can remain even partially sane.

If this were a strictly logical presentation of the role of pure mathematics in physics, we should, of course, have to begin with *definitions*: "What is mathematics, what is physics, what is a relation, etc.?" There are numerous stunt definitions of these disciplines. From the eminent author of *Marriage and Morals* (and other somewhat more recondite works) we have long since learned that "pure mathematics is the class of all propositions of the form 'p implies q'." This means that mathematics is really symbolic logic, a subject already aptly described by another distinguished mathematician. Recall the famous dictum of Tweedledee in *Through the Looking Glass*. Said he to Alice in connection with some weighty mental matter: "Contrariwise, if it was so, it might be; and if it were so, it would be, but as it isn't, it ain't. That's logic." This

remark about logic makes us the more ready to accept the even more notorious deliverance of the philosophical earl above quoted that "mathematics is the science in which we never know what we are talking about nor whether what we are saying is true." College students support this view wholeheartedly even when they do not understand its implications.

Just as familiar are the stunt definitions of physics, from the good old engineering version that "physics is the science of the ways of taking hold of things and pushing them" to the metaphysical cliché: "physics is only a state of mind." And speaking about metaphysics reminds us of the three-way comparison someone has made of philosophy, mathematics, and physics:

Philosophy has been a human activity for ages, and philosophers have long sought to understand the universe. As a result of their efforts they have at length come to know almost *nothing* about *everything*. On the other hand, the mathematicians, who have been equally eager to understand, have through the course of the centuries achieved the proud position where they know almost *everything* about *nothing*. Finally the mere physicist, a modest and humble soul, having tried very hard, has at last been able to learn a little *something* about *something*.

This sort of thing could be continued indefinitely, but this is enough for our purpose.

To the average physicist the fondness for generalization suggested in the parable just quoted is undoubtedly the chief characteristic of the pure mathematician. To be sure the physicist considers *he* is working mathematically when to the accompaniment of much perspiration and some profanity he evaluates a certain infinite integral (usually approximately!) or solves a certain recalcitrant differential equation (also usually approximately!). But the pure mathematician assures him that all this is not really mathematics—it is merely manipulating symbols and is probably wrong anyway, certainly so if it fails to come within the range of the appropriate existence theorems. For

the pure mathematician is never interested in special cases unless they are strictly pathological. To him the proper aim of mathematical analysis is the establishment of the most general conclusion from the smallest number of restrictive hypotheses. Moreover, he refuses to permit any trace of uncertainty in the conclusions he draws; every element of his reasoning is scrutinized in the most severely critical manner, and anything that anyone else has to say about his reasoning is scrutinized with the same meticulous care. The results are open to the inspection of anyone who cares to examine a treatise on analysis. It will there be found that the pure mathematician would far rather say with absolute certainty something about continuous functions which are *not* differentiable than about functions which *are* differentiable. By the same token he feels even more pleasure in being able to say something about functions which are not even everywhere continuous.

This desire for maximum generality coupled with maximum rigor is very laudable. We certainly could stand a lot more application of the mathematician's ideal of rigorous, honest thinking in our daily lives and social relationships. Yet it cannot be denied that the emphasis on generality has, for the physicist, its inconvenient side. For it usually happens that the more general the theorem, the less it says which is useful to one interested in a specific application. Moreover, physicists are occasionally annoyed by the penchant of the mathematician for proving that under such and such conditions a solution of a certain equation exists without in the least indicating how to find it. But the latter is just the problem the physicist is worrying about. Actually he has little doubt about the existence of the solution: if the equation really represents a physical situation, there must be a solution.

But let us return to the question of the nature of mathematics, particularly in its relation to physics. It is appropriate to listen to what two distinguished physicists have said about it. In an address before the mathematical and physical section of the British Association at Liverpool in 1870, Clerk Maxwell made the following remarks:

As mathematicians we perform certain mental operations on the symbols of number or of quantity and by proceeding step by step from more simple to more complex operations, we are enabled to express the same thing in many different forms. The equivalence of these different forms, though a necessary consequence of self-evident axioms, is not always to our minds self-evident, but the mathematician who by long practice has acquired a familiarity with many of these forms and has become expert in the processes which lead from one to another, can often transform a perplexing expression into another which explains its meaning in more intelligible language.

Maxwell then went on to state succinctly what we do as *physicists* in an attempted description of natural phenomena. In elaborating on the relation between the two forms of activity he finally comes to the part which appears particularly apropos of our present discussion. I quote again:

There are men who, when any relation or law, however complex, is put before them in a symbolical form, can grasp its full meaning as a relation among abstract quantities. Such men sometimes treat with indifference the further statement that quantities actually exist in nature which fulfil this relation. The mental image of the concrete reality seems rather to disturb than to assist their contemplations.

But the great majority of mankind are utterly unable, without long training, to retain in their minds the unembodied symbols of the pure mathematician, so that, if science is ever to become popular, and yet remain scientific, it must be by a profound study and a copious application of the mathematical classification of quantities which lies at the root of every truly scientific illustration.

There are, as I have said, some minds which can go on contemplating with satisfaction pure quantities presented to the eye by symbols, and to the mind in a form which none but mathematicians can conceive.

There are others who feel more enjoyment in following geometrical forms, which they draw on paper, or build in the empty space before them.

Others again, are not content unless they can project their whole physical energies into the scene which they conjure up. They learn at what rate the planets rush through space, and they experience a delightful feeling of exhilaration. They calculate the forces with which the heavenly bodies pull at one another, and they feel their own muscles straining with the effort.

To such men momentum, energy, mass are not mere abstract expressions of the results of scientific inquiry. They are words of power, which stir their souls like the memories of childhood.

For the sake of persons of different types, scientific truth should be presented in different forms, and should be regarded as equally scientific, whether it appears in the robust form and the vivid colouring of a physical illustration, or in the tenuity and paleness of a symbolical expression.

So much for Maxwell! We are now ready for the opinion of the other physicist referred to above. The story goes that at a Yale faculty meeting at which the discussion grew long-winded (as it is apt to do on such occasions) on the comparative merits of courses in English, mathematics, modern languages, etc., the usually silent professor of mathematical physics finally rose and said with decided emphasis: "Mathematics is a language."

I have often wondered whether this is the basis on which students of mathematics in liberal arts colleges secure election to Phi Beta Kappa! I doubt whether Gibbs had this in mind, if he actually made this statement, which after all is merely an abbreviated form of Maxwell's comments. Mathematics is the language of physical science and certainly no more marvelous language was ever created by the mind of man.

In view of this it would certainly strike an ignorant bystander as paradoxical, or at least somewhat surprising, that the general public and indeed many physicists view with a mixture of suspicion and repugnance the increasing use of mathematics in physics. It is well known how difficult it is to make college students really use in elementary and intermediate college physics the mathematics they have learned in mathematics courses. A few years ago I thought it was possible to detect a trend toward the closer co-operation between elementary mathematics and physics, which would permit the early use of the calculus in physics teaching. This is not so clear today. The war situation should discourage hasty generalization, but I think we must reckon on the odd repugnance of the generality of mankind to deal with an abstract symbolism. This is a psychological problem of great interest though of great difficulty and one not within my competence. I am told by certain authorities that many persons are constitutionally unable to think mathematically, i.e., in terms of abstract symbols. This has always struck me as curious, for it seems to me that all persons who think logically at all are effectively thinking mathematically whether they are willing to admit it or not. The learning of a special symbolism is a mere device to facilitate logical thinking, and unwillingness to

learn it probably reflects human inertia more than human incompetence. The equation of continuity of an incompressible fluid in the form $\nabla \cdot (\rho \mathbf{v}) = 0$ may leave the average citizen cold but he ought to be made to realize that he actually understands what it means if only he grasps the significance of that famous bar room which, I understand, exists in the city of San Francisco: it has two doors and whenever anyone enters one door, someone *has* to leave by the other. It is not at all a difficult concept to get hold of, viewed thus pictorially. Like the hero in Molière's play, who was astonished to find out that he had been talking prose all his life, many of our contemporaries would doubtless be amazed to learn of the amount of mathematics they really know!

Mathematics is a language marvelously adapted to the description of natural phenomena, but we must be careful to impress on everyone the necessity for understanding what the language says. Too many persons think of theoretical physics, for example, as mere juggling with symbols and symbolic relations. But the mathematical manipulation is meaningless without an understanding of the physical content. No matter how abstract a concept is, even if it is a quantum mechanical ψ function, a definite physical significance should be attached to the concept, which follows it wherever it wanders throughout the mathematical analysis. If we were more careful to follow this recipe we might prevent theoretical physics from becoming a mere meaningless algorithm for the prediction of the results of experiments. In this connection I like to recall what Maxwell had to say about Faraday in the preface to the first edition of the celebrated *Treatise on Electricity and Magnetism*. It will be remembered that he began the composition of his work with the supposition, common at that time, that there was a decided difference between Faraday's way of looking at electrical phenomena and that of the continental school of mathematicians. However, as he proceeded with his study of the *Experimental Researches in Electricity*, he became convinced that Faraday's method of description was also a mathematical one, even if not expressed in the conventional mathematical symbolism of the time. Actually

we now recognize that Faraday originated the field concept in electrical science and that Maxwell's great contribution was in translating Faraday's theory into the accepted mathematical notation of the nineteenth century. But the point for us to note is that in the use of his geometry of lines of force, Faraday reasoned mathematically in very decisive fashion. It is not at all unlikely that the more powerful modes of nonmetrical mathematical thinking typified by modern topology may ultimately find as useful an application to modern physics as Faraday's original geometrical notions.

We are all familiar with the fondness physicists display for analogies. They are used freely in teaching and in certain fields they have proved a powerful research tool. Think in this connection of the utility of electromechanical analogies in the field of communications. Their outstanding success has led to a peculiar situation: in order to explain to an electrical engineer, for example, how a mechanical filter works, it is necessary to replace the actual collection of masses and couplings by an equivalent set of inductances, capacitances, and resistances. Only then does he really understand it! Now the point about this which is relevant for our present purpose is that the successful use of the method of analogy depends solely on the mathematical equivalence of the schemes used to describe the phenomena in question. It takes little thought to see that such analogies never could have been developed from physical intuition based on observation alone. Certainly a cylindrical tube with alternate constrictions and expansions in its cross section bears no remote resemblance in its physical appearance to an iterated combination of coils of wire and condensers. It is only when we examine the two structures mathematically that we recognize that the tube behaves ideally with respect to acoustic wave transmission the same as the inductance-condenser structure with respect to electric wave transmission. Certainly there is a tremendous gain in the efficiency of our thinking in our recognition that both structures can be considered as energy-transmitting systems which are selective with respect to frequency.

The above illustration suggests the impor-

tant role played in the progress of physical methodology by the choice of an appropriate notation which can be applied successfully to a wide diversity of phenomena. An example closely allied to what we have been discussing is found in the impedance notation for the ratio of a pressure analogue to a flow analogue. It is scarcely an exaggeration to say that this notion alone has opened the book of acoustics to electrical engineers who would have turned pale at the very mention of the name of Lord Rayleigh. It seems only fair to admit that it did not take the impedance notation to make the theory of acoustics clear to Lord Rayleigh; however, it certainly has made the use of acoustics much easier to hundreds of persons, and this is justification enough.

There is a converse to the picture. The mind of man is a strange thing; not content to economize by using the same mathematical notation to describe the most diverse phenomena, it feels that it gains a deeper insight into one particular section of experience by describing it with a wide variety of mathematical methods. A mathematics professor of mine many years ago used to say that it is much more illuminating to solve one problem by two or more different methods than any number of problems by the same method. It is hard to convince beginning college students of the validity of this point of view; they have apparently been too carefully conditioned against it by their secondary school education. But I think we must all admit that this is an idea which has led to tremendous strides in physics as well as in mathematics. Everyone knows that it is perfectly possible to develop the theory of elastic media in terms of sets of simultaneous equations connecting stress components with strain components. But think how much more insight is gained in these problems if we translate the results into tensor analysis notation! Maxwell stressed this point of view in his remark that "mathematics is the art of saying the same thing in many different ways." We must not be too much disturbed if the language tends to grow more abstract as this process evolves.

The reference to the word "art" in Maxwell's remark serves to remind us that much attention has been paid to this aspect of

mathematics as something created by the mind of man, possessing no necessary connection with his external environment and being in this sense akin to all other artistic creations, transcending common experience and common sense. What relation, if any, does this view have to physics? Certainly the study of history shows that early mathematics developed from the desire to describe nature more precisely than in terms of common language. Nearly all the early celebrated mathematicians were also natural philosophers. However, in more recent times, mathematicians have preferred to construct their abstractions without reference to the physical world and work with entities "that never were on land or sea." Physicists are apt to grow impatient with this sort of thing and label it mysticism or worse. It might be fairer if we compared it with music or art as an expression of man's emotions. G. H. Hardy in his recent book, *A Mathematician's Apology*, expresses openly the conviction that what he calls "real" mathematics must be justified as art if it can be justified at all—it has no other defense. Like poetry or music it promotes and sustains a lofty habit of mind. For one of the most enthusiastic panegyrics on mathematics from this standpoint I can recommend nothing better than the introduction to Lord Brougham's biographical sketch of D'Alembert. Brougham was an amateur mathematician along with his other versatile traits. Physicists may not like his treatment of Thomas Young and certainly he was pretty far wrong in his estimate of the wave theory of light, but we cannot help being impressed by the sonorous Victorian prose in which he emphasizes the depth of the pure mathematician's immersion in his subject, his attention abstracted from all lesser considerations, and his mind reflecting a calm and agreeable temper. The sublime effect is a bit weakened indeed when he solemnly asserts that "instances are well known of a habit of drinking being cured by the intensity of attention to mathematical researches." Moreover, we learn also that "an inveterate taste for gambling has been found to give way before the revival of an early love of analytical studies!"

On the whole, physicists should be glad that pure mathematicians exist and in fact ought to be willing to subsidize them if their limited means allowed. For it is becoming more and more clear that the pure mathematics of today will be the physics of tomorrow. This does not mean that the fertilization of mathematics by physics is over. On the contrary, the creation of new mathematical methods for the solution of physical problems proceeds at an accelerated pace. The vast amount of interest in operational methods initiated by Heaviside's operational calculus and the even newer work on nonlinear systems provide good illustrations. This is the field of mathematical physics—a genuine branch of mathematics, too often confused in popular parlance with theoretical physics, which is physics and not mathematics. If I may insert a parenthetical remark, it would be better not to use the terms mathematical physicist and theoretical physicist as synonyms—it is not wholly a trivial matter when it comes to placing people in jobs where they can do the most good.

It is becoming more keenly realized that mathematical physics is a more difficult field of endeavor than pure mathematics. For the pure mathematician creates his own problems, and if he strikes one he cannot solve, he usually manages to find another somewhat like it which he *can* solve. But the mathematical physicist has to take the problems which nature provides—he cannot dodge them. For this reason it is very important for the progress of physics that as many as possible of the best mathematical minds of the world shall devote their attention to mathematical physics. Under the impact of war this is taking place to a greater extent than ever before in this country. We may well hope that the process suffers no check!

As long as man retains his curiosity about his environment, he will try to describe nature, and as long as he expresses his interpretation in terms of relations among apparently diverse phenomena, he will continue to use mathematical reasoning; this will remain true whether we are concerned with metrical or nonmetrical aspects of experience. Of one thing we may be sure: physics without mathematics will forever be incomprehensible.

THIS BRAVE NEW WORLD AGAIN

By CHARLES F. MULLETT

AMID the prolific blue-printing of the "brave new world," education has been amazingly neglected. To this contention some will reply that I am overlooking the feverish, even frenetic, activity of reconstruction committees; but such groups, I am convinced, are considering means, not ends, and their policies will be at best trivial and at worst vicious in producing technicians, not educated people. The consequence will be to lay the groundwork of another national crisis and international catastrophe.

The record of the universities in wartime is indeed no cause for pride. Whether attention be directed to the eagerness with which administrators run off to their paltry gatherings or muddy the waters with their busy work; to the false promises made to prospective students (come and get anything you want); to the pathetic betrayal by scholars of their fields of knowledge either by sheer prostitution to practical ends or by pursuing with disgraceful haste every opportunity of getting their country to serve them and so finding a temporarily laudable excuse for leaving their obligations behind; or, finally, to the rewards out of all reason and justification that administrators have heaped upon men who have departed to do jobs that any WAC could perform much better—the story, I repeat, is a sorry one.

The professors who have remained at home have in many instances completed the picture by finding in the war an alibi for riding off in every direction except the narrow, hazardous path of scholarship. The university administration, following its orthodox creed of minimum efficiency, has further encouraged the degeneration of its intellectual tissue by devoting the major part of its facilities and thought to preparing to continue the same sort of half-education that the war has forced upon us—often without faculty protest—and by offering no adequate, let alone enthusiastic, support to its scholars.

In the midst of this shadow-boxing with problems already accepted as a *fait accompli* some few voices have been raised in criticism,

and no doubt many obscure men have gone quietly and steadily about their business—the advancement of learning. These men, articulate or inarticulate, know that new departures, even ruthless departures, in procedure are necessary. At the same time they insist that before embracing the novel the universities must consider again and again the basic and eternal needs of man and the world. Such a scholar as Henry Sigerist, who has been pondering educational problems from many angles and for many years and who may be taken as the most outspoken apostle of the ideas herein set forth, has constantly pursued new methods and welcomed new views.¹ On the other hand and as constantly, he has not confused the path with the goal or techniques with education. His informed interest in both history and science has given him perspective and depth; his international contacts and social viewpoint have provided breadth.

With many thoughtful and sensitive men this philosopher has been deeply distressed over the cultural and intellectual blackout clouding the world since 1910. This era has destroyed both values and matériel. To offset the collapse of civilization—temporary though it be—culture in the old-fashioned sense is more necessary than ever. Its therapeutic virtue was demonstrated in the recovery of France after 1871 when Bernard and Pasteur, Flaubert and Zola, Saint-Saëns and Frank, Cézanne and Renoir completely redressed the political humiliation. The German republic after 1918 showed many signs

¹ Mr. Sigerist has stated his position in the following articles from which any quotes in the present pages are taken: "War and Culture," *Bulletin of the History of Medicine*, XI (1942), 1-11; "American Spas in Historical Perspective," *Ibid.*, 133-47; "On the Threshold of Another Year of War," *Ibid.*, XIII (1943), 1-8; "The University's Dilemma," *Ibid.*, XIV (1943), 1-13; "The Study of Medicine in Wartime," *Ibid.*, XV (1944), 1-14; "The University at the Crossroads," *Ibid.*, 233-45. He is seriously considering bringing out these essays along with some others of the same sort, written or projected, in book form. The desirability of this is altogether obvious.

of recovery through its support of science, education, and diverse cultural enterprises. Conversely the collapse of France after 1918 may owe something to the cultural nihilism of Cocteau, Celine, and the innumerable "ists" who played with bits of things; and the suffocation of hopeful beginnings by the new barbarism may in large part explain the failure of republican Germany to realize its own renaissance.

Superficially at least, not all cultural activities suffer from the war. Science, history, art, for example, enjoy wide support, but all too often their moral and intellectual values are submerged. In science, technology flourishes at the expense of understanding. To offset this the history, sociology, and philosophy of science must receive attention. The war makes demands and seems to offer great opportunities in such a field as medicine, yet there is greater need than ever to retain standards of research and clear appreciation of values in the face of emergencies.

In the historical field, propaganda, current events, and mere "background" have obviously all too often superseded history. Nevertheless,

every situation we come to face, every problem that we are called upon to solve, are the results of historical development and trends. The way we act is largely determined by the picture we have of our past. Without sound knowledge of history we can act instinctively and opportunistically, but we cannot act intelligently. . . . The reconstruction of the world after the war will call for a mobilization of all resources of historical scholarship we possess, and it is therefore extremely important that the work that is going on at the moment be not interrupted. Studies that may seem far remote from the present problems may all of a sudden become of very acute interest.

If, moreover, we are to move from competition to co-operation and from technology to a broad social philosophy, attention to the social sciences, especially to law, is scarcely less important. Equally essential are cultural studies in institutions and in languages and literatures.

War is to society what illness is to the individual, not merely evidence of a collapse but, on the positive side, both an opportunity and a necessity to re-examine values. The makers of history are the philosophers (but lest some persons feel inclined to preen themselves, let it be remembered that I said *phi-*

losophers, not grubbers on the surface of philosophic problems). Napoleon influenced history not as a soldier or even as an administrator, supreme though he was in both capacities, but as the personification of the ideas of the French Revolution. "The most formidable weapon the United States possesses in this war is not its Navy, not its Air Force or Army, but its Declaration of Independence and Bill of Rights." The philosopher is the nation's intellect. He alone enables mankind to keep abreast of the times by supplying honest, courageous self-criticism. Fascism regiments, we are all agreed; but are the artist and researcher in America truly free? "Is there not a regimentation of a more subtle kind, by the exigencies of the market?" Is there not a regimentation when gadget men of whatsoever sort in the universities get the largest salaries and the greatest consideration and respect from the administration, or when the supposed leader of scholarship, the graduate dean, openly expresses lack of sympathy with pure research and gives his support to "practical" items no matter how trivial?

Much is made of the necessity for eighteen workers in the rear to supply one man in the fighting line. This does *not* account for the scholar and the teacher, the poet and the artist. These needed men will determine whether the real victory is won. Nevertheless, one of the most hopeful features of the war era is that, for example, despite the accelerated and concentrated program in medicine, the courses in the History of Medicine at Johns Hopkins (all elective) drew more students in 1942 than ever before. Moreover, four medical students asked for a course in the philosophy of Plato, making it clear that they wanted not his science but his philosophy at large. This had never happened before. All over the country university men in the service have written back insisting on their profound realization of cultural values. These men have been tremendously stirred up by the war; they feel that they are in the midst of a gigantic historical process the nature of which they cannot define; they justly feel that historical and sociological analysis can help them to clarify their thought. If the university cannot help them, who can?

It is wrong for a university to fold up in time of war and turn into a mere technical institute. It must impart technical knowledge and skills, to be sure, hurriedly and concentratedly, but it must do it in the academic way. It is the method that makes it, and the personality of the teacher. Philosophy can be taught without special courses, in discussing the design of an airplane; instruction in sociology can be given while poison gases are being prepared. There is more philosophy, psychology, and sociology involved in every clinical case that turns up in the hospital than the specialists could dream of.

It is a truism that technology has everywhere outrun sociology; with all our means we cannot produce desirable ends (thus giving rise to the conviction that the means must justify the ends, rather than allowing the ends to justify the means). Destruction has outrun construction, yet if the war period last long, we must adjust ourselves to it as we adjusted ourselves to the economic depression. We must make decisions now and not postpone them, because "after the War" may actually be many years from now and it may then be too late. "We must not drop our cultural activities. In a total war they are a potential also and we may find it difficult to resume them later. Shostakovich's Seventh Symphony was a great Russian victory too." Myra Hess, giving noonday concerts of Bach and Beethoven in the midst of the Blitz, challenged Englishmen no less than Dunkirk, or "blood, sweat, and tears." At a time when Americans were cancelling all learned conventions, the hard-pressed Russians had time to hold large meetings commemorating the tercentenary of the birth of Newton.

Now that so many of us are in the armed forces, those of us who are left behind must work twice as hard as before, must give up every thought of comfort and readily accept living on a rapidly decreasing standard that will not soon rise again. There will be many casualties on the home front too because the human heart can stand only a certain amount of stress, but the readiness to sacrifice one's life for a just cause is not a privilege of the young people alone.

The war, of course, has opened many possibilities in education and science; the training in languages, technology, cosmopolitanism is bound to bear good fruit if the worms are checked in time. In particular the war may revolutionize medicine from a social viewpoint. Experience has more than once preceded science in medicine; and what is true there applies elsewhere. The possibili-

ties for good, however, should not disguise the ready-made alibi which the war has supplied to the lazy, the superficial, and the downright mistaken. "Our universities will be facing an extremely critical situation which . . . is entirely independent from the war." Some years ago the ambitious young researcher wanted to become a full professor and head of his department so that he could guide it along the line of his ideals. This aim functioned well enough in the days of small departments. "It was often assumed and usually correctly, that a good researcher is a man who thinks clearly, and that a man who thinks clearly can express himself clearly and therefore must be a good teacher." Now universities are full of top-heavy departments and the chairman is an administrator who has no time for research. Yet if chairmen are administrators and not researchers, the university and the department will suffer, for "when practice is dissociated from research, it soon degenerates into mere routine."

Universities have often been slow to accept new circumstances, as they were in the fifteenth century and later, although Leyden and a few others quickly responded to the demands of the time. While the slowness is not an unmixed evil, it has often had the effect of driving out of the universities men and activities that might have remained to general advantage. Through the nineteenth century "students were instructed by men who were actively engaged in research and it was in the universities that the sciences took their great development." Now students receive instruction from men whose researches "ended the day they were appointed to some famous chair as a reward for outstanding researches" or from men whose researches stopped with their doctoral dissertation. If the universities continue to reward men only by making them administrators or by paying high salaries only to administrators (as is almost invariably the case), the scholar will seek other types of appointment. Thus if care be not taken, research will be divorced from the universities and seek refuge in private institutions ready to sponsor research and encourage original contributions to knowledge. Such a development might well prove fatal to humanistic

studies because the number of private institutions interested in these studies is pitifully small. Moreover, private institutions cannot in any case truly replace universities which without research will become mills imparting secondhand knowledge and offering only sterile education. The researcher needs students who will at once stimulate generalizations and force him to think through his problems clearly. Universities should create "distinguished" chairs for researchers in time to gain good from the holders and allow them to give a few, highly significant courses upon the essential content of which they have already spent untold hours and need only the opportunity and the stimulus to present what they alone know, to chart areas that they alone have explored; they should have time to give undivided attention to the larger aspects as well as to the minutiae of their investigations.

Every effort should be made to capitalize on the great tradition of learning, though this tradition may at times be a handicap as well as a stimulus; we need both a past and a future. Students in the midst of a tradition must realize their obligations and not coast on its reputation. There is always need for intellectual curiosity, critical judgment, imagination, proper values, social consciousness, correct English, and knowledge of working methods. These indeed constitute the best preparation for graduate study and are in a measure the vehicles of self-education.

In particular the duty of students is to become not merely good doctors, lawyers, merchants, but also good citizens. The lack of genuine education permits many physicians who are critical scientists in their own profession to "succumb to the most primitive type of propaganda and lose every critical sense as soon as social and economic issues are involved." Indeed any profession or vocation must be viewed "not as a technique but as a social function."

Such a view can only come when universities realize their proper place in society; and one of the chief ways is the advancement of learning. Yet they have so frequently operated on the law of minimum efficiency—getting the cheapest instructor and discouraging the only person who makes the univer-

sity something other than a teacher's college or a vocational school. When the lack of students offered scholars the excellent opportunity to pursue their own investigations, many universities instead of taking advantage of that situation thrust their professors into army programs, the least rewarding instruction in many cases that ever man could offer. The demands were so tiring that research terminated, and in fact so great a fatigue, moral as well as physical, came over some men that they had not recovered for months afterward. Professors were, of course, in some measure to blame for their own predicament. Throughout the war they have in all too many instances eagerly dropped the work of a lifetime—the experience, knowledge, and interests of twenty years or more—to piddle. They have run off to Washington or anywhere else that would provide escape from the daily pursuit of learning. They wanted to contribute to the war effort, yes, but what a betrayal of learning that it became more important to engage in large-scale doodling than to advance the boundaries of their fields of knowledge.

The real scholar, taking the much harder way—doing his job as patiently and persistently as in the piping times of peace and order—knew that he must redouble his efforts even though, and here was his highest hurdle, he often doubted the value of his investigations. The ideas of an Elizabethan virtuoso, the career of an eighteenth century colonial agent, the legal status of religious minorities in England since the Reformation, the evolution of medical ideas, these seem so remote, so unrelated to the present crisis, so unimportant beside a "hush-hush" role in Washington. To make the matter worse, the university administration offers no leadership. How much we need presidents and deans who will lead, who, forbidding professors to piddle, will encourage scholars to continue those explorations where no one has ever gone, who will not surrender to every passing fad because it seems pertinent to the present crisis.

Treason to their responsibilities is, of course, the measure of the universities' failure. They are in the doldrums because their staffs are peeling potatoes, filing cards, and

teaching boys a modicum of information that bore the boys themselves. They are in a crisis because many professors believe that the ingenious devices for teaching army students will do for education, that a great gain will be accomplished if students can be run through in an ever shorter and shorter time. Universities and their staffs have forgotten that indoctrination, a smattering of techniques, a nodding acquaintance with superficial information is not education. They are in a crisis because they did not take advantage of the war's depletion of students to encourage scholars to do research instead of making more tools of research. They are in a crisis because they are no longer genuinely interested in learning.

Time and a proper intellectual metabolism are vastly more important than all the gadgets devised by curriculum builders. Not hours but time, not courses but work, a slow process of assimilation and maturation, these produce an educated man. Instead we face the plague of the half-educated, not merely for tomorrow but for years to come. Technicians we shall have in abundance and continue to have, but be it remembered that because there are few qualified young instructors today, ten years hence there will be few well-balanced, well-educated young professors. The professors in service have already lost touch with scholarship and with ideas; even if they come back with the intention of carrying on their researches, they may easily become discouraged or, what is even more vicious, they may be intoxicated with techniques or the "practical" nature of what they are doing. In either case intellectually they will offer nothing to genuine students. A man who has been forced by, or who has readily succumbed to, circumstances and has abandoned his laboratory or study for a number of years very rarely finds his way back to it. What is no less tragic is that the men who stayed on in the universities and kept learning alive may either be worn out or smothered under routine.

Yet, as has been remarked, the war only precipitated crises that were already apparent. Such disintegrating factors as lack of real encouragement to research—the amount of money spent by administrators gadding about the country would subsidize scholar-

ship beyond the dreams of avarice—refusal to touch controversial subjects, the unhappy split between the "teacher" and "researcher," and the lack of intellectual leadership on the part of the university administration had been long at work. It cannot too often be insisted that "where there is no research there cannot be academic instruction" on a high plane, and if research is carried out of the universities, both they and research itself will suffer.

What must universities do to halt this disintegration and avoid their ultimate intellectual collapse? First, they must vastly extend their research activities and free scholars to do research, and I mean *research*, not gadgets. It is an inexcusable waste to have a man spend twenty or more years acquiring knowledge and experience in a field of learning and then compel him to spend his time teaching high school subjects, with which he is none too familiar, to freshmen, failing to do research because he cannot get a few dollars for travel, photostats, or typing assistance, and "discussing with committees whether a set of windows should have Venetian blinds or not."

Secondly, graduate instruction must not be allowed to become merely the imparting of technical knowledge: we must avoid that narrow specialization that makes a formula or bibliographical apparatus alone knowledge. The broader reaches of any subject under heaven can be intelligently discussed by intelligent people; and when the specialist resorts to jargon, he is proving his own lack of education and arousing suspicion as to the essential value of his subject, for it is notorious that the most specious subjects in the curriculum are most riddled with technical jargon and tools. The latest intricate device of International Business Machines is *not* an educated man; nor is a person spilling the formulae and barbarous lingo of his subject, for he is really little more than an animated (not much more animated and far less impressive and accurate at that) business machine himself.

Thirdly, undergraduate instruction must be solid. There can be no shortcuts, and the classics, the fundamentals, must get the attention. History, not Social Studies, must play a large role in this education: "a study

of contemporary life without historical and philosophic foundations remains by necessity superficial and meaningless." Let the pendulum swing back toward quality, and let the best, not the poorest, students set the pace. They crave something substantial, something fundamental, and they may help to educate their poorer brothers.

Finally, universities must remember that they are part of the world with responsibilities to perform. They should contribute to society, but their contribution must be their own, not that of the Rotary, the church, the home, the American Bar Association, or any

old Marching and Chowder Club. Their contribution is knowledge, a constantly expanding knowledge substantiated by learning, refined by understanding, and directed toward the highest values. We must steadily realize that our actions are the instruments of our ideas and ideals and that they in turn are the products of our philosophy. Our philosophy is the result of our larger education, and the universities if they properly fulfil their function will, not merely by their instruction but also by their values, establish the quality of that education and hence of all the things that stem from it.

MEANS AND ENDS

*Among the ancients spake the master Greek
Democritus, "the atoms move and change
The face of nature. Thus the new and strange
Springs from intrinsic laws which man may seek."*

*Augustine saw in fate the arbitrary rules
Imposed by God and subject to suspense;
To saints by revelation known, not sense
Nor gained by mankind's hard won mental tools.*

*Which view has brought us farther on the way
To the good life? Does either tell man where
To blaze his trail, for means are not the end?
Shall hedonistic impulse fill the day?
Shall we for mansions here or yon prepare?
Unto what goal shall we our best expend?*

—JOHN G. SINCLAIR

LITERATURE AND SCIENCE: A STUDY IN CONFLICT

By CHARLES I. GLICKSBERG

THE conflict between literature and science, like the much more ancient one between science and religion, is still going on. Men of letters face the choice of becoming "slaves" of science (the strategy of submission) or remaining intransigent and independent (the strategy of revolt). The logic of events, the pressure of tradition, and a complex of professional motives have forced them to accept the gage of battle. Since they cannot resign themselves to the sovereignty of science, they must perforce revolt.

But what are they to revolt against? There is the rub. There is little agreement among literary men as to what they most object to in the scientific discipline. The warfare between literature and science turns into a war of scattered forces attacking irregularly on a wide, confused front. If the writers were clear in their mind as to what they were fighting *against* (they know what they are fighting *for*), there might be some hope of reconciliation or of waging war to a decisive issue. As it is we are left in a befuddled state.

What are some of the explicitly voiced objections against science? First of all, the scientific method is condemned on the ground that it is analytical and empirical; it is therefore fragmentary, not organic and universal. Second, it is concerned primarily with the realm of facts, not of values; it gathers data, it does not interpret and evaluate them. Third, instrumentalism may be a good laboratory technique; it is not a way of life. Fourth, literature differs in kind from science; it has its own laws and techniques; as an autonomous field of expression it is not susceptible of scientific analysis. Finally, the philosophy of science is squarely opposed to that of literary humanism.

The fatal weakness of those who attack scientists for their narrow vision and mistaken assumptions is that they themselves take a number of things for granted which are altogether dubious. By appealing directly to the innermost intuitions of the

reader, they set up an untenable dichotomy between reason and intuition, head and heart. A refined sensibility, we are given to understand, is capable of a more profound apprehension of reality than the mind of the physicist—as if the scientist possessed no intuitions at all. Another and no less fatal error they commit is to assume a transcendental order of existence to which they, by virtue of their refined sensibility and clairvoyant intuitions, have special access. Fortified with such specious arguments, they call for a liquidation of our extraverted, mechanical, materialistic life and a return to the true inner self, a regeneration of the soul, a lifting of the individual from the naturalistic to the spiritual and creative level of the absolute.

All this sounds highly inspiring if one were only able to grasp concretely what is meant by these abstractions. The prestige of literature is at stake, and the litterateurs will not surrender without a desperate struggle. Why should "knowledge" be reserved for the scientific discipline, while literature—well, what does it do? It expresses emotions, it organizes attitudes, it communicates the wholeness and unique particularity of an experience, but it is not concerned with either knowledge or truth. It does not deal with ideas or their logical relationship or their empirical validity. Therefore, the defenders of literature hasten to demonstrate that literature utilizes a different linguistic function from that common to science, and that artistic truth is somehow superior to the truths of science.

Why so many writers and critics should feel a constitutional antipathy towards science is one of the mysteries psychology must explore, but this antipathy is at the root of the conflict that is still raging today. In the weather-beaten perspective of time, the result of this ideological struggle may prove as important in its effect on the course of civilization as the outcome of World War II. The litterateur, defending his profes-

sional interests, has become a forceful propagandist in a movement designed to undermine the validity of science. Even if the scientist wished to do so, he is not in a position to counteract this noisy stream of propaganda. His aim is to humanize and universalize the philosophy of science, to recommend the virtue of suspended judgment based on observation and critical reflection. He would extend the use of the method of empirical rationalism not only to specialized fields of investigation but also to the realm of politics, economics, ethics, social behavior.

It is indeed strange to find men of letters fulminating against science as if it were a fatally destructive Juggernaut, a Frankenstein. Both in England and the United States, the intellectuals give vent to hysterical squeaks of indignation at the rapid spread of scientific ideas. Some powerful emotional leaven must be at work to call forth this violent attitude of opposition, too irrational in substance to be explained on purely logical grounds. There is the shrill outcry that science spells the death of individuality. Impersonal, quantitative, precise, it would standardize not only commodities and methods of production but also men. It would reduce the world, "so various, so beautiful, so new," to a single, mechanical unit, whereas literature is based essentially on the qualitative principle. The creative life is concerned with values, tradition, ideals—elements which are alien and antipathetic to the scientific outlook.

Science, it is true, endeavors to arrive at objectivity in its observations and conclusions, thus tending as far as possible to eliminate the subjective, the bias of temperament, the fallibility that is human—all-too-human. Even if we grant this much, it is still difficult to understand why the writers are so envenomed in their protests. The argument directed against the mechanical aspects of science is a disingenuous rationalization. Something more fundamental is at stake: two world-attitudes are in conflict. If the truths of science prevail, and they are making irresistible headway on all fronts, then the pretensions of literature to a higher, unassailable, eternal truth must be abandoned.

Some critics have stressed the idea that literature is the product of a mysterious, mystical intuition. Others have maintained that it is a criticism of life, concerned with moral values and with the projection of beauty otherwise unapprehended and unexpressed. It voices the universal through the medium of the particular; it affirms and gives imaginative life to the enduring faith by which men live. But if science strips off the veil of divinity from the ark of creation, if the sublime and universal truth of literature is shown to be neither sublime in origin nor objectively valid, if beauty and intuition are disintegrated by the ultraviolet rays of scientific analysis, then what is left for the writer? Literature becomes no more than a source of refreshment, a form of play, the sublimation of superfluous or frustrated energies. It can provide enjoyment and even illumination but not certitude.

Thus at the heart of this embattled controversy a fierce professional rivalry manifests itself. A rivalry perhaps unconscious in nature, but the writers who pitch angrily into science are, whether or not they realize it, defending their vested interests as purveyors of a "higher" truth. That is why they are in such a stew of revolt. In their wrathful desperation they seize upon any missile that lies ready to hand and fling it at the Mephistophelian head of Science, the dark angel destroying the religious sense and casting men adrift on a shoreless sea of doubt. The gods are unseated, and there is nothing to take their place. Man finds himself rootless, depersonalized, anarchic, in a universe of meaningless flux. Arbitrary and limited in outlook, science is considered guilty of a gross and inescapable narrowing of the field of vision. Inescapable because by definition it confines itself to conclusions only about those processes and events which can be known and verified. What do these objections amount to? Nothing more than this: Science is not religion, science is not mysticism, science is not prophecy, science is not art. But who ever said it was?

If literary men persist in their uncritical assaults on science, naïvely distorting the scientific outlook, if they continue to concern themselves with intuitions of a "higher"

truth, then the value of their work is bound to suffer. Science is no longer something external and abstract; it is an intimate part of the world we live in, already an integral part of ourselves, our perceptions, our thoughts, our cultural heritage, and to ignore it is a bit of inexcusable folly.

The attitude of the humanist scholar towards science is psychologically revealing. Three ways are open to him: first, he may reject the scientific discipline, exposing its limitations and contradictions; second, he may surrender his special privileges and accept the discoveries and doctrines of science; third, he may attempt a compromise whereby science is allotted its restricted sphere of influence while literature retains its own. The first method has been tried and resulted in conspicuous failure. The second solution of the problem was for a time highly popular. Since science had come to stay, was there any good reason why literary scholarship should not become "scientific"? Humanistic scholars would beat the scientists at their own game. Thus there was instituted the fetish of research, the religion of the authenticated literary fact, the mania of resurrecting forgotten texts and manuscripts. In the intoxication of engaging at last in "scientific" research, the work of interpretation and critical appraisal was forgotten.

But the scholars could not long fool themselves with the talisman of scientific research. This was getting them nowhere. What were they doing but turning out a race of glorified pedants, dry-as-dust scholars without taste, understanding, or critical appreciation. The method was supposed to be scientific, but the results were neither literature nor scholarship nor science. There was no high purpose, no unifying principle, behind these labors. Scholars had gone astray because they had, so they professed to believe, capitulated to the scientific discipline. It was, on the contrary, their lamentable misconception of the function of science, their crude failure to understand the nature and limitations of the scientific method, which had trapped them in this cul-de-sac.

If both methods had failed to work, the third was still available: a form of com-

promise. To each would be assigned a kingdom which it could govern: to science what belonged to science, to literature what was distinctively the province of letters. Thus the troubled waters were to be stilled. Unfortunately the truce was soon broken, for the simple reason that the literary scholars entertained a peculiar conception of the demesne they had been assigned to rule as their own. Science was arbitrarily cut off from the sphere of value, which then became a function exclusively reserved for the humanities. "Surely," Professor Norman Foerster declares in *Literary Scholarship*, "it is time for scholars in the humanities to make clear to themselves the fact that science is not the only respectable kind of inquiry." Now what can one mean by a "respectable" kind of inquiry? Even if we grant that literary scholarship must forge its own methods, why this emphatic repudiation of science? Why make the gratuitous assumption that values, which are the special concern of the humanities, lie outside the jurisdiction of science? Though more temperate in tone, Professor Foerster's attack is substantially like the one Irving Babbitt delivered in 1908 when he published his *Literature and the American Scholar*.

Only one conclusion is possible: men of letters, whatever the plausibility of the rational arguments they advance, are opposed to science because it destroys the picture of the universe in which they wish to believe. If the statements of science are true, then the as-if fictions of poetry must be discarded as sheer fantasy or make-believe. Yet there is no reason why the discoveries of science, once they are taken into the mental climate of the race, cannot, as William Wordsworth believed, become the nutriment on which poetry can feed. The advance of science does not sign the death-warrant of poetry. Whether or not he accepts the scientific outlook, the poet cannot sweat it out of his system. Whether he likes it or not, he inherits the culture of his age, and the culture of our time is predominantly scientific. There is not a major poet writing today whose work does not in some measure reveal the revolutionary impact of science on his thinking, his interpretation of the world, his

philosophy of values. The enforced isolation of science from traditional literary culture is an unsatisfactory state of affairs. A culture that deliberately divorces itself from the dominating ideas of its time dooms itself to pedantic futility.

The real issue at stake, then, is whether literary truth can be put into a separate category, entirely distinct from scientific truth. If literature presumes to communicate "truth," then this truth, no matter how derived or expressed, must compete on the same terms and in the same open market with scientific truths. There can be no exemptions, no dialectical distinctions. Either literature voices truth or it does not. If it does, then it must be prepared to meet the challenge of science.

In *The Nature of Literature*, another of the numerous attempts to explain literature in its relation to science, language, and human experience, Professor Thomas Clark Pollock contends that the function of science is to communicate referential meaning, while that of literature is to express and communicate the *wholeness* of experience, experience in all its immediacy and complexity, its aliveness and unabstractable realness. Once he accepts these limiting conditions, the scientist is neatly trapped. For "reality" cannot be defined or exhausted in referential terms. We get abstractions and generalizations, not the actual reality of human experience. Literature is presumably unique because it communicates the quality of experience, not abstractions from these experiences. In short, literary expression is alleged to be closer to the stuff of life, furnishing a more vital approximation to reality, than the abstractions of science. This theory leaves out the fact that the experience which it is the function of literature to communicate is also an abstraction. There is no correspondence, except a purely symbolic one, between experience and expression. A lyric kiss is but the fugitive shadow of a kiss.

This brings up the problem of truth in poetry, for poetic truth is a special instance of literary truth. Must emotions be forced into the channels of the reasonable and the valid, or can they lead a charmed life of

their own, needing no excuse for being? There have been critics like Coleridge and I. A. Richards who argue that poetic beliefs have no connection at all with factual propositions. In *Communications*, Karl Britton concludes that:

... imaginative writing has its quite distinctive "truth" and "falsity," its "reasonings" of the heart that Reason does not know; its "meaning." But for these different features of imaginative writing, the terminology of science and history is inappropriate and positively misleading. For the "truth" that is *peculiar to poetry*—its *validity*—is simply its value for men: this can be assessed, and statements *about* the value of poetry are themselves either true or false in the straightforward sense of these words. And the "reasons" of poetry are those emotional connections which are fundamental to poetry; they are not founded upon any relations of implication.

There is a flaw in this defence of poetry. If the "truths" peculiar to poetry are simply their value for men, apart from the rational-empirical truths of science, then the implication holds that poetry can entertain any truths at all so long as these are pleasing to the emotional needs of readers. Poetry therefore becomes a sublimation, a therapeutic, a land of make-believe, a blissful dream-world, a realm of delightful fictions. Such a defense draws a sharp line of cleavage between the truths of poetry and those of science. Actually no such cleavage exists. In their efforts to reach to the heart of Nature, many poets have turned eagerly to the scientific dispensation. When the poets of the Romantic school, led by Wordsworth, insisted that writers should keep their eye on the object and report truly what they beheld, they achieved a creative triumph of the scientific method. Wordsworth might ridicule the botanist who peeps and botanizes on his mother's grave, but he himself used his observation of plants and birds and natural scenery to excellent effect.

Exactly what science could do for poetry is a question that, until recently, had never been seriously asked. The problem, however, had not been correctly grasped. The question is not what science can do for the poet. For that matter, what can Nature do for the poet? It is not Nature, as Coleridge sadly realized, but the interpretation of Nature that counts supremely: what the

poets themselves as creative agents help to contribute. Similarly with science. If it has not exerted a fructifying influence on poetry, is the fault to be imputed to science or to the ignorance of poets, their adherence to convention, their subservience to tradition? Science has broken no promises for the simple reason that she has never made any. Science, like Nature, is there for the taking; those who have the eyes to see and the ears to hear as well as a generous share of imagination and talent, can fuse this rich diversity of new material into a brilliant creative synthesis. There is no warrant for the arbitrary dualism which sets science apart from literature, or which brings them into opposition.

The poet cannot turn to science in the expectation that it will solve his problems for him, but he cannot solve them himself without its aid. It can furnish him with a foundation of related and reliable knowledge, but it cannot supply him with talent and an integrated philosophy of life. It can point out the way of reaching truth, but he must walk the whole way himself. Science can teach him all that it has so far discovered concerning heredity, the influence of the cultural environment, the structure of the human personality, the psychology of instincts and emotions and thought, but it cannot make him feel this knowledge in his blood, assimilate it organically within his being. Ideas can be stated; they cannot be communicated. Hence if the poet is foolish enough to turn to science in the belief that it will give him a ready-made aesthetic philosophy, a definitive answer to all questions, a basis for the complete understanding of all problems, he is bound to be disappointed.

And there are a million and one things that a thorough knowledge of science will not do for the poet. Just as wide and varied experience and deep feeling will not necessarily make a poet, so training in the meaning and implications of the scientific method will not add one iota to the poet's talent or facilitate his mastery of form and technique. Skill in the handling of language, imaginative richness of texture, the evocation of mood, the wedding of sound and sense, the strong undercurrent of rhythm, these come

as the result of training and practice and are not conditioned by the nature of the material at the poet's disposal. The linguistic medium is different in structure and aim from that of science.

But there is no escaping the impasse created by the allied problems of literary value and truth. If literature, as is confidently asserted, is the locus of value and gives expression to truth, these cannot, except in form, be distinctive and unique. The pluralistic assumption that there are all kinds of truth, with its corollary that literature yields a form of truth not only different from, but vastly superior to, the empirical truths of science, that is the assumption which has caused so much damage and confusion. The proposition is either true or false. Our contention is that it is totally false.

Poetry cannot presume to possess a validity that is superior to, or in conflict with, the findings of science, but there is no reason in the world why the poet, like the philosopher, who has mastered the scientific culture of his age should not know anything about life. In his iconoclastic book, *The Literary Mind*, Max Eastman had underlined this very point: that poets, as poets, do not know anything about life. Why should they "know" any less than Eastman, who is himself a poet? Is the mind of a Robinson Jeffers or Archibald MacLeish or W. H. Auden (to name but three significant contemporary poets at random) less richly endowed, less perceptive and understanding, than the mind of a psychologist or biologist? Poetry does not merely suggest the immediate quality of experience; it also passes judgment on that experience even if only by an emotional conclusion that it is good or bad.

No, science does not advance by driving poetry out. The advance of science simply imposes a greater intellectual responsibility on the poet. If poetry cannot in time assimilate the conclusions of science, it is doomed. True, it cannot feed on electrons and protons, on conditioned reflexes and the theory of relativity. Science universalizes the relations of things; literature clings to the individual experience. Exactly! Therefore there is no conflict between science and poetry. If the latter represents the world

as man discovers it, the representation must correspond in some measure to the comprehensive picture of reality furnished by science. For science too reports the world as man finds it.

Though poetry and science have different aims, they have much in common. Not that poetry, steeped in scientific lore, will degenerate into guides to conduct or that poets will fashion their work according to the latest bulletin from the laboratory or clinic. Spontaneity will have to remain, freedom of choice, genuine individuality of expression. Though the literary mind is heavily handicapped in an age of science, this handicap is its greatest promise of future achievement. In his *A Hope for Poetry*, C. Day Lewis declares that modern poets "are making strenuous attempts to tap the power of science by absorbing scientific data into their own work: by 'scientific data' I mean the myriad new sense-data which scientific development has put before us." For before scientific data can be rendered accessible to the poet, it must percolate through the general consciousness, become an integral part of the social environment.

From the time of Aristotle down, the critics have been laboring hard to make it out that literature, particularly poetry, was by some divinity of circumstance, some infusion of genius and inspiration, truer than history or science, a superior kind of revelation. Our object has been not so much to separate the two disciplines—literature and science—as to bring them fruitfully together. Each can profit from the other. Science can make the writer more scrupulous, more critical, more objective, less inclined to mistake the will-o'-the-wisps of the imagination for the truth of reality. It can bring him closer to the world of sense, enable him to realize the complexity of the universe, render him more humble and earnest in his search. In turn he must be willing to submit his conclusions to the empirical test, not to believe that his truths somehow partake of transcenden-

tal essences, that he portrays a "higher Reality." He must accept the responsibility imposed on one who ventures to make the truth of life known.

Once a writer accepts the scientific outlook, his isolation would end. Poets reared in the scientific discipline would discover that no disastrous consequences followed, that their will was still "free," that they still had an infinite variety of experiences to write about. It is not the function of the poet to interpret the conclusions of science in verse; he is not a popularizer of chemistry, physics, biology, and anthropology. What he draws on as relevant to his art and fruitful in its influence is the philosophy of science, the scientific synthesis. His task is to humanize science as it applies to the varied problems that man must face, the fate he must undergo on earth. He does not paraphrase the theory of relativity; he shows it in action in his poetic universe. He does not preach doctrines; he incarnates attitudes, beliefs, and these are strongly colored by the scientific outlook. Those poets who accept the philosophy of scientific humanism will abandon their futile war against science, convinced that science offers them a real and spacious world for the exercise of their talents and a rich soil for the use of their imagination and insight.

Literature can be restored to its high estate only on the condition that it renounce both the folly of laying claim to possessing a special and superior brand of truth and the even greater folly of denying that it has any concern at all with either knowledge or truth. Both philosophies are mistaken and self-defeating. For the sake of their own salvation, writers must reaffirm the vital and redeeming principle that literature, rooted in reality and born of experience, is essentially a criticism of life, and that this criticism will prove most efficacious when it works in alliance with the scientific outlook. Literature has everything to gain and nothing to lose from such an alliance.

SCIENCE ON THE MARCH

AN ARABIC BLOCK PRINT

Very few people indeed, even among bibliographers of old books, are aware of the fact that the process of printing from carved wooden blocks, which the Chinese invented and Gutenberg developed into printing with movable type, had reached the Moslem world long before it was known to Europe, and was practiced in Egypt up to the middle of the fourteenth century. Although, as early as 1894, the Austrian scholar, Josef von Karabacek, signalized the existence of several examples of block prints in the Archduke Rainer collection of Arabic papyri, parchments, and papers (now in the Vienna National Library), his statement escaped the attention of the general public, and also of most specialists, until an American scholar, Thomas Francis Carver, assistant professor of Chinese in Columbia University, pointed out this impressive circumstance in his admirable book, *The Invention of Printing in China and Its Spreading Westward*, New York, 1925 (reprinted twice since the author's untimely death).

Carver, who was assisted in his inquiry by the outstanding authority on Arabic papyrology and book science, Professor Adolf Grohmann of the German University in Prague, emphasized the fact that, besides the block prints in Vienna (Karabacek listed only seventeen, but they are said to number about fifty) and in the Egyptian Library of Cairo (the number of which is unknown), very few specimens of these peculiar products of early printing have been preserved. Six in Heidelberg, one in Berlin, and two in the British Museum are known so far; possibly others may be buried among the miscellaneous items of other libraries and museums, still waiting for identification. As a matter of fact, only an experienced eye may be able to recognize them for what they are.

No wonder, therefore, that the unique example (unless others should be detected) of an Arabic block print in America lay hidden for over thirty years in the repositories of the Museum of the University of Pennsylvania without anybody noticing its extreme rarity. In a manuscript catalogue of the

Arabic papyri, parchments, and papers in the Museum, most of which were purchased in 1910, No. E 16311 is listed as follows: "Vellum. Small Arabic amulet, written on one side. The first line, in a decorative panel, reads 'lâ ilâha illâ Allâh' [there is no god but God] followed by the formula 'bismi illâhi al-rahmâni al-rahîmi' [in the name of God, the Merciful, the Compassionate]."

It was only because the present writer, while going through the papyrus collection of the Museum, was reminded of what he had read in Karabacek and Carver, that he was able to recognize that that diminutive and



AN ARABIC BLOCK PRINT
OF THE FOURTEENTH CENTURY. UNIV. OF PA. MUSEUM

inconspicuous scrap of extra-thin parchment, not larger than two inches by one-and-a-half, was an invaluable specimen of block printing, the more precious inasmuch as all other examples, with a single exception in Heidelberg, are printed on paper, whereas the Philadelphia print is on parchment.

The Chinese method of printing from

wooden blocks never became popular among the Arabs. The cutting of the capricious curves of the Arabic script, where most characters are tied together as in our cursive script, out of a hard wooden surface proved too toilsome and the results too little attractive to meet the taste of a sophisticated public. Block printing was therefore confined to short and cheap texts, consisting either of selections from the Koran or of prayers, mostly used as charms and amulets; and of that kind are the contents of all known Arabic block prints.

The Philadelphia specimen is no exception. In its present state it is fragmentary. With a high degree of probability, it represents the uppermost part of a long and narrow scroll which was originally divided into several sections and has been cut immediately below the first: a minute part of the heading of the second section is still extant. Each section had a heading, written in ornamental Kufic script and surrounded by a decorative pattern. The heading of the first section, as stated above, reproduces the formula "There is no god but God" printed in white letters on a black background. Twelve lines follow, which contain the beginning of a prayer, introduced by a quotation from the Koran and consisting of pious ejaculations: "In the name of God, the Merciful, the Compassionate. God bears witness that there is no god but He, and the angels and those possessed of knowledge standing up for justice. There is no God but He, the Mighty, the Wise (Koran, 3:16). O Maker of everything which is made! . . . O Protector of every

stranger! O Eternal without change! O Present never absent! O Winner never won! O Learned never taught! Thou art God who . . ."

The letters are extremely minute and since they were cut on a hard wood present an angular shape which lacks the slender elegance of Arabic calligraphy. Many of them, although differentiated in the regular script, appear here in the same shape, a shortcoming which increases the difficulty of reading the text.

As stated above, block printing appealed but little to the Arabs and was never widely spread there. After the middle of the fourteenth century its use was discontinued, and the very recollection of it vanished totally. The Philadelphia fragment apparently belongs to the latest products of that craft, the importance of which the Arabs failed to recognize as they failed to foresee the tremendous success which was reserved to it in the future. Actual printing with movable type entered the Arabian world at a much later date, and for two centuries after Gutenberg's first achievements Arabic printed books came out only from European presses, the oldest being a Christian Prayer Book printed in Italy in 1512.

In spite of this, or rather because of this, the few known examples of Arabic block prints rank with the rarest bibliographic treasures, and the tiny scrap of parchment in the Museum of the University of Pennsylvania may be of greater value than many a heavy block of carved stone preserved in its premises.—GIORGIO DELLA VIDA.

BOOK REVIEWS

MINERALS, PLANTS, AND MEN

Lectures on the Inorganic Nutrition of Plants. D. R. Hoagland. 226 pp. Illus. 1944. \$4.00. Chronica Botanica Co.

NOT in any sense an exhaustive monograph on the subject, this compact and readable book nevertheless succeeds admirably in focusing the reader's attention on a number of the more salient problems of the mineral nutrition of plants. The author's viewpoint is a broad one, but concision of presentation has been attained by basing most of the discussion on the data of a limited number of key investigations. Most of the material was originally presented as the Prather lectures of 1942 at Harvard University.

The subject matter is discussed in seven streamlined chapters, called "lectures." The first of these deals largely with the soil solution, the role of soil colloids, and other soil properties, and serves as an orientation for the following chapters. In the second lecture relations between the micronutrient elements and plant growth are considered, especial attention being given to the role of zinc. The following chapter is probably the best short summary now available of recent work on the mechanism of the absorption and accumulation of salts by plant cells, a line of investigation with which the author's name has long been associated.

In the fourth lecture the problems of the upward movement and distribution of inorganic solutes are discussed. Considerable attention is given to recent investigations in which radioactive isotopes have been employed in blazing the trail which mineral salts follow in their movements through the plant. The next chapter gives consideration to some of the problems of growing plants in artificial media such as sand and solution cultures. No attempt is made to discuss the details of these techniques but rather to give a general perspective of these methods as an experimental approach to problems of the mineral nutrition of plants.

In lecture six some of the biochemical problems associated with salt absorption are discussed. Emphasis is placed on possible relations between organic acid metabolism

and protein metabolism on the one hand and salt absorption on the other. In the final lecture one of the essential plant elements—potassium—is singled out for detailed discussion. The problems of the soil-plant-atmosphere system, which repeat themselves according to a somewhat different pattern for each of the essential mineral elements, are illustrated in terms of this element.

Illustrative experimental material is drawn largely from the work of the author and other California workers. The book therefore serves the very useful purpose of epitomizing the important contributions to this branch of plant science by several groups of workers in that state in recent years. There are numerous figures, twenty-eight full-page plates, an author index, and a subject index. The binding and format are up to the general high standard of the monographs in this series. It is not a book that will stand idle on the shelf.—B. S. MEYER.

LOOK AT THE WORLD

Look at the World. Richard Edes Harrison. 67 pp. Illus. \$3.50. 1944. Alfred A. Knopf, New York.

THE question of how best to portray the spherical surface of the earth on a flat map has taxed the ingenuity of cartographers for centuries. Distortion exists in all of the various types of projections, and in each type the pattern of distortion is different in character and amount from that of the others. We might draw an analogy by comparing photographs of a landscape which were taken from different viewpoints.

The average man's idea of what the world looks like has been derived almost entirely from one standard type of map—the conventional Mercator map of the world. In spite of its general acceptance, this map exaggerates the size of areas as we approach the Polar regions, and our ideas of the world are thus influenced largely by the fact that we always see it presented from this single viewpoint. A different perspective might result in a change in our ideas.

In *Look at the World*, Richard Edes Harrison gets away from the banality of basing all maps on the conventional Mercator pro-

jection and focuses attention on viewing the world from a number of entirely different perspectives. It is very interesting to study the geography of the world anew from such different angles.

Most of the maps in this atlas are on the orthographic projection, which approximates the view one gets when looking at a small globe, but other projections are also used. The cartography is excellent, and the atlas has been arranged in a most artistic and instructive manner. A gazetteer index in the back of the book enables one to locate unfamiliar places.

The author contends that the conventional showing of north at the top of the page prevents a flexible view of geography, and accordingly most of the maps are shown with north at various angles. This provides a new and interesting experience in studying maps from such points of view. However, some will still prefer north at the top of the page in order that they may more readily and more easily orient themselves as far as direction is concerned.

The author deserves credit for focusing attention on maps that do not follow the orthodox style but present the world from a different viewpoint. Only in this way will any progress be made.—G. S. BRYAN.

OLD ORAIBI

Old Oraibi, A Study of the Hopi Indians of Third Mesa. Mischa Titiev. 277 pp. Illus. 1944. \$4.50. Peabody Museum of American Archaeology and Ethnology, Harvard University.

THE Hopi Indians of northeastern Arizona, because of their somewhat isolated location and a marked resistance to outside influences, have retained so much of their aboriginal culture that they furnish a fruitful field for ethnological investigations. These westernmost of the Pueblo peoples occupy towns situated on, or at the foot of, three mesas known as First, Second, and Third Mesa—as they are approached from the east—and one farming village 40 miles west of Third Mesa in the direction of the Grand Canyon. Dr. Titiev's main objective was a study of the Hopi of Third Mesa, their towns of Oraibi, Hotevilla, Bakavi, New Oraibi, and the distant farm colony of Moenkopi. Conditions at Third Mesa are

particularly interesting because prior to 1906 Oraibi was the only town located there. The others were founded subsequent to that year by people from Oraibi. As a knowledge of the former populace of Oraibi is necessary to an understanding of all the villages, most of the investigations were carried on among its old inhabitants.

Dendrochronological evidence, the tree-ring calendar, shows that Oraibi was founded before 1150 A. D., and as it has been occupied continuously since that time, it is often referred to as the oldest inhabited community in the United States. From the coming of the Spaniards in 1540 until 1906 it was the largest and most important of the Hopi towns. Internal dissension and strife developing over a long period of years culminated in 1906 in the secession of about half the population and the establishment of Hotevilla on the mesa seven miles north of Oraibi. The next year Bakavi was founded on the mesa about a mile southeast of Hotevilla. In 1910 another exodus got under way, and New Oraibi at the foot of the southern end of the mesa was the result. Other groups have drifted westward to Moenkopi where, although still holding allegiance to Oraibi, they have settled permanently. In 1906 Oraibi had a population of over 600 living in some 150 households. Today it numbers about 100 occupying 25 houses. The remaining dwellings, through disrepair, are rapidly falling into ruin.

Dr. Titiev gathered all existing information about the social organization of Oraibi and in his report gives a full description of the manner in which it functioned prior to 1906. He also analyzes the factors leading to the split, discusses the dynamics of the disintegration of the town, and follows the elements of the population in their dispersal and founding of the new villages. The data on the social organization are complete and present a clear picture of that phase of Hopi culture. Discussions of the intricacies and significance of the kinship system and the reciprocal behavior of kindred unquestionably will appeal to ethnologists but may prove somewhat heavy going for the average reader. This is not the case, however, in the consideration of the amorphous Hopi state, the disintegration of Oraibi, and the sug-

gestions on the use of Oraibi ethnology in the interpretation of Pueblo archaeology.

The second part of the report relates to Hopi ceremonialism, the secret societies, cults, customs, rituals, and meaning of Hopi religion. The material presented is both informative and entertaining reading and gives insight into some aboriginal concepts of the origin and purpose of life and its continuity after death, of the nature and functions of the various gods, and of the significance of the rites performed in their honor. From his study Dr. Titiev concludes that the Hopi took whatever material measures they could to offset the dangers of crop failures, enemy attacks, devastating disease, internal dissensions, etc., and finding them an inadequate guarantee of the security they desired, they turned to the supernatural for assurance. In brief, the Hopi religious beliefs and practices were devised as a supernatural buttress for the weak points in the social organization.

Several aspects of Hopi culture that are only summarized in the discussions of the social organization and ceremonialism are presented in detail in a miscellany which comprises the third part of the report. In this way full information is made available without confusing the main trends of thought in the first two parts. In an appendix, constituting part four, are lists of the major ceremonies, names of chiefs, the ritual calendar, data on the ceremonial chambers and associated shrines, and other supplemental items. The report also contains a comprehensive bibliography and a topical index and glossary of native terms. No study was made of the linguistics, as other investigators are working on that problem.

Although basically an account of the culture as found at Oraibi, Dr. Titiev's monograph applies to Third Mesa in general and, on the strength of a comparative study, the Third Mesa situation may be regarded in the main as typical for all the Hopi. Specialists in the study of the American Indian will find much of value in it, and it will be particularly helpful to those primarily concerned with the aboriginal Southwest. The general reader can gain from it interesting information about one group of the Pueblo Indians.—FRANK H. H. ROBERTS, JR.

ROCKETS

Rockets, The Future of Travel Beyond the Stratosphere. Willy Ley. 287 pp. illus. 1944. \$3.50. The Viking Press.

THE present military use of rockets and jet-propelled planes and bombs has focused attention on them and has given rise to many misconceptions. *Rockets* is a book that will clear up these misconceptions and allow a much clearer picture of the potential and reasonable uses to which rockets may be put. Although written as a nontechnical book, a technical reader will find sufficient material to form a good starting point for further thought and calculations. The inclusion of some simple calculations (mostly in addenda) does not spoil the presentation for the layman.

The first half of the book presents an extensive historical background of astronomy and astronomical thought, as well as a history of rockets. This is done to show that although the past history of rockets has been a cyclic one, alternating between war and amusement uses, the future will see other and more useful applications. There are some very interesting facts about early use of war rockets. The perfection of rocket design accomplished by Congreve in the early 1800's will surprise most readers.

Since Mr. Ley was intimately connected with the VfR (German Rocket Society) from its inception, his detailed description of its work is quite complete and good. The diagrams and explanation of the devices developed are no less clear and lucid than his description of the way they behaved in experiments. His qualifications for writing this book extend even further than his personal contact with rocket research in view of the fact that he is a professional writer specializing in scientific history.

The description of the "Meteorological Rocket" is excellent. One would think it a description of an accomplished fact. It is convincing.

The oversimplification of the mathematics throughout the book is probably justified in view of its purpose. The discussion of orbits for interplanetary rocket travel will go a long way to clarify the problem. He presents a clear, coherent picture for the general reader. The explanation as to why

orbits should be used for all interplanetary travel is to the point.

The discussion of the subject of gravity is not so good, but it is short. On the other hand, the concept of a "Terminal in Space" is enticing. It is shown that the formation of an artificial satellite about 500 miles above the surface of the earth is a project that might be undertaken quite soon. It would be a rocket that would take up a permanent revolution around the earth and act as a laboratory, or even a point of departure for other and more distant travels. As a matter of fact, a proposition of three such satellites is developed in some detail. One is an inner one revolving around the earth in about an hour and three-quarters; another is about 3,000 miles up and completes a revolution in about three hours and twenty minutes; the third travels in an ellipse, acting as a transport between the other two. Although plans are set forth to man these satellites and construct rather elaborate facilities, one may suppose that a remote-control "automatic" laboratory would be a more attractive project for some time to come. Many interesting facts about the behavior of such a "space building" are brought out.

The mathematics given in the notes and addenda in the back of the book leave a lot to be desired. They should act as a stimulus for someone to straighten out and complete them. An elaborate bibliography covers more than one hundred references in English, German, French, and Russian on all aspects of the subject. Its inclusion indicates that Mr. Ley has read about all there is to read on the subject. He has written a good book.—H. C. VERNON.

NORTH AMERICAN WOLVES

The Wolves of North America. Stanley P. Young and Edward A. Goldman. 636 pp. Illus. 1944. \$6.00. American Wildlife Institute.

THIS monograph, dealing with one of America's most picturesque wild mammals, is a fine example of what might be done with respect to many other members of our native fauna, especially those, like the wolf, that may be in danger of vanishing. The volume is a paragon of completeness and should be the standard work on these master carnivores for many years to come. Both authors are members of the Division of Wildlife Re-

search of the U. S. Fish and Wildlife Service. They have clearly divided the authorship of their book, Mr. Young being responsible for Part I, on the wolf's "History, Life Habits, Economic Status, and Control," and Major Goldman for Part II, "Classification of Wolves." Mr. Young has had ample opportunity to observe wolves firsthand, having himself been once a predatory-animal hunter of the U. S. Biological Survey in the Southwest, later serving in charge of that bureau's Division of Predator and Rodent Control. Major Goldman is a veteran biologist—a specialist in mammalian taxonomy and ecology and in game management—and has explored more of the United States and Mexico biologically than probably any other living person.

Mr. Young's account is essentially documentary and represents years of digging into natural-history literature to exhume the record of the wolf's history. It is an attempt to collect all wolf lore and knowledge having any historical or scientific import. The author quotes copiously from the early naturalists, explorers, and pioneers, and it is evident that he has read virtually everything there is to read on wolves, past and present. (There are eighty pages of bibliography.) The result is a singularly exhaustive story, the sequence of presentation being as follows: Distribution of the wolf in North America; Habits and characteristics; Natural checks, parasites, and diseases; Economic status; Measures used in wolf capture and control; and History of wolf depredation and cooperative Federal wolf control. The wolf is described as symbolizing "power, ferocity, courage, fighting ability, and ruthlessness," and the biographer of the animal thus finds himself deploring those qualities that have made it a scourge to the stockman and an enemy of most other wildlife, while at the same time admiring the animal's nobler qualities and marveling at the firm place it has attained in legend, language, and literature. Mr. Young writes:

From a biological as well as from an historical viewpoint, the wolves, linked with the dogs, are of surpassing interest as an outstanding group of predatory animals. In the more remote parts of North America, especially in Alaska, northern Canada, and on the other extreme, even in Mexico, suitable habitats remain where these large killers can exist in no direct contact with man. No reason is, therefore,

apparent to us why they should not always be tolerated, and even accorded a permanent place in the fauna of the continent; rigid control, however, must be maintained where their presence clashes with human welfare.

The history of the wolf, therefore, is mostly a story of man against wolf, with man now pretty much ahead in the conflict.

Major Goldman's section of the book constitutes a taxonomic revision of all the native North American forms of the genus *Canis* except the coyotes. His purpose is to dissolve the confusion that has long existed in wolf nomenclature, to provide a standard for identification, and "to afford a substantial foundation for the use of future workers in bringing together more comprehensive knowledge of the wolves of the world." He recognizes twenty-three subspecies of the gray wolf (*Canis lupus*) and three geographic races of the red wolf (*Canis niger*), describing his material as follows:

The revision is based mainly on a study of the extensive wolf material brought together especially in connection with the predatory animal control work conducted since 1915 by the Fish and Wildlife Service (formerly the Biological Survey), and other collections in the United States National Museum, now numbering 1,190 specimens. Many of these are skulls without skins, and in some cases skins without skulls. These specimens have been augmented by 178 from other American museums, making a total of 1,368 examined. The assemblage has included the type or topotypes of most of the described forms. This unparalleled wealth of material has afforded a basis for accurate appraisal of the range of individual and geographic variation, and has led to satisfactory conclusions in most cases.

Major Goldman's systematic account is accompanied by distribution maps and by tables of cranial measurements, which constitute one of the important characters in the group. There is also a complete "gallery" of skull photographs.

Mention should be made of the many excellent illustrations the book contains, particularly the six full-color plates from paintings by Walter A. Weber and Olaus J. Murie. These latter show especially the various color phases found in both the red and the gray species of wolves.

The book would have profited by a more diligent proofreading and by closer attention to some of the finer points of typography and bookmaking, but in general it is a distinct credit to both the authors and the publish-

ers; and they may take pride in having provided so useful and worthy a contribution to our knowledge of the natural history of this continent.—PAUL H. OEHSER.

SCIENCE IN CALIFORNIA

Science in the University. Members of the Faculties of the University of California. 332 pp. Illus. 1944. \$3.75. University of California Press.

On the cover of the book it is stated by the editors that "This Volume is offered as a token of appreciation to the State of California and its citizens, who for three-quarters of a century have generously supported the University through the medium of public and private funds." The idea is so sound that one cannot help commending those who not only thought of it but actually saw it through. It is doubly gratifying to find that the attempt at informing the citizens of a state of the kind of research they are supporting has achieved the success to which the essays in this volume testify.

The book is not an effort to appease the public by giving it a glimpse of what is going on in one field of research or another; rather it constitutes a genuine and serious compilation of nineteen essays most of which are vibrant records of what scientific research involves and of the problems it faces and their relevance to knowledge and practice. No doubt the average reading and thinking citizen will find some essays more readable than others, but this is as it should be. The research fields of some of the faculty members are so specialized that the only useful function such scientists can perform is to summarize or review the background of their work. Others present their own work as well as the difficulties they confront and convey an intimate picture of the scientific quest for knowledge. Still others summarize their own researches in such organic fusion with the larger field as to present excellent accounts of both.

Of exceptional merit in this last group are the essay of J. H. Hildebrand on solubility, which is not only a model of lucidity and compactness but is also spiced with mellow philosophy, the essay by C. L. A. Schmidt on amino acids and proteins, C. B. Lipman's article on longevity, and D. R. Hoagland's on plant nutrition. Of equally high merit both for readability, scope, and content and

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The revision is based mainly on a study of the extensive wolf material brought together especially in connection with the predatory animal control work conducted since 1915 by the Fish and Wildlife Service (formerly the Biological Survey), and other collections in the United States National Museum, now numbering 1,190 specimens. Many of these are skulls without skins, and in some cases skins without skulls. These specimens have been augmented by 178 from other American museums, making a total of 1,368 examined. The assemblage has included the type or topotypes of most of the described forms. This unparalleled wealth of material has afforded a basis for accurate appraisal of the range of individual and geographic variation, and has led to satisfactory conclusions in most cases.

Major Goldman's systematic account is accompanied by distribution maps and by tables of cranial measurements, which constitute one of the important characters in the group. There is also a complete "gallery" of skull photographs.

Mention should be made of the many excellent illustrations the book contains, particularly the six full-color plates from paintings by Walter A. Weber and Olaus J. Murie. These latter show especially the various color phases found in both the red and the gray species of wolves.

The book would have profited by a more diligent proofreading and by closer attention to some of the finer points of typography and bookmaking, but in general it is a distinct credit to both the authors and the publish-

ers; and they may take pride in having provided so useful and worthy a contribution to our knowledge of the natural history of this continent.—PAUL H. OEHSER.

SCIENCE IN CALIFORNIA

Science in the University. Members of the Faculties of the University of California. 332 pp. Illus. 1944. \$3.75. University of California Press.

On the cover of the book it is stated by the editors that "This Volume is offered as a token of appreciation to the State of California and its citizens, who for three-quarters of a century have generously supported the University through the medium of public and private funds." The idea is so sound that one cannot help commending those who not only thought of it but actually saw it through. It is doubly gratifying to find that the attempt at informing the citizens of a state of the kind of research they are supporting has achieved the success to which the essays in this volume testify.

The book is not an effort to appease the public by giving it a glimpse of what is going on in one field of research or another; rather it constitutes a genuine and serious compilation of nineteen essays most of which are vibrant records of what scientific research involves and of the problems it faces and their relevance to knowledge and practice. No doubt the average reading and thinking citizen will find some essays more readable than others, but this is as it should be. The research fields of some of the faculty members are so specialized that the only useful function such scientists can perform is to summarize or review the background of their work. Others present their own work as well as the difficulties they confront and convey an intimate picture of the scientific quest for knowledge. Still others summarize their own researches in such organic fusion with the larger field as to present excellent accounts of both.

Of exceptional merit in this last group are the essay of J. H. Hildebrand on solubility, which is not only a model of lucidity and compactness but is also spiced with mellow philosophy, the essay by C. L. A. Schmidt on amino acids and proteins, C. B. Lipman's article on longevity, and D. R. Hoagland's on plant nutrition. Of equally high merit both for readability, scope, and content and

for interest to the general reader besides, are the contributions by J. R. Oppenheimer, C. E. ZoBell, R. W. Chaney, L. Miller, J. M. D. Olmsted, Knight Dunlap, and S. J. Holmes. These essays are by no means stereotyped reviews. Each is replete with original and stimulating ideas which make the material both uniquely interesting and informative.

Of special interest are the series of articles dealing with geological and meteorological aspects of the California Coast. This local color adds much to the glamor and logic of the book since it is but fitting that a University pay some attention to local needs and local features. Somewhat in a class by itself is the article by R. B. Goldschmidt which discusses a difficult and specialized problem concerning the nature of the gene. It is an illuminating and stimulating essay, conveying the difficulties confronted in laying the foundations for a basic theory in science.

The other essays in the volume are equally rich and lively. All nineteen contribute to make the volume a true cross section of University research in modern times and of methods in the presentation of material. This is not a plain-talk report to the average citizen; rather is it a report to the citizen who has considerable familiarity with the broader outlines and problems of science. It is a pioneering start, and a venturesome university might even try in the future the kind of report that can actually reach every member of the public.—MARK GRAUBARD.

THE PASSING OF THE EUROPEAN AGE

The Passing of the European Age. Eric Fischer. 214 pp. 1943. \$2.50. Harvard University Press.

In this philosophical book the author presents the theory that the civilization of our present-day world had its origin in Europe, that the seeds of that European civilization have been transplanted into all the other continents where they flourished, took on color from the new environment, and matured into a new cultural entity. During its day Europe not only supplied the seeds of the most aggressive world civilization but at the same time dominated that civilization in all parts of the world. It maintained an essentially European age.

As the seedlings of transplanted European culture matured in distant lands, they all followed rather similar patterns of growth. First, they established the cultural practices and national traditions of their particular homelands in a new and foreign environment. Then followed a period of selection during which the good importations were preserved, the bad ones eliminated, the indifferent ones tolerated, and new adaptations developed to fill gaps in the inherited body of cultural equipment. As changes occurred and became well established, the new lands developed national consciousness of themselves and in many cases openly broke with the mother country, as did the United States with England and the Latin American countries with Spain and Portugal. In other cases the break was less violent but nevertheless effective, as the British Dominions with their mother country.

In the next stage in this evolution the transplanted cultures began to dominate and began to throw seeds of their own propagation back to the parent land. That is the stage in which we stand today, according to Dr. Fischer, and the stage that justifies the title of his book.

This book is an optimistic treatment of a subject and process that Spangler and others have considered with considerable pessimism and gloom. Dr. Fischer sees, not the passing of European, or Western, civilization, but rather the passing of an age during which Europe dominated most of Western culture. His is a theme of hope for the future, a future of balanced cultural forces in which peace can be achieved.

The Passing of the European Age is stimulating reading. The author supports his thesis with numerous examples drawn from all parts of the world. Since it is a philosophical treatment of the subject, the illustrations are qualitative rather than quantitative. They leave us at a point of departure from which we should like to proceed into a more detailed analysis of the subject. But, though brief, the book is well worth reading for its optimistic and hopeful attitudes concerning our changing, growing Western civilization.—A. K. BORTS.

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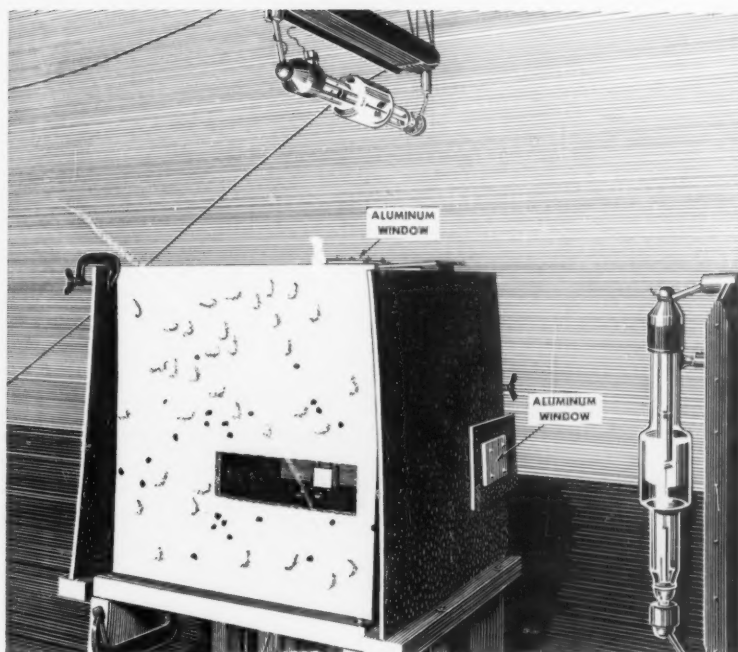
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